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TECHNOLOGY DEMONSTRATION OF DEDICATED COMPRESSED NATURAL GAS (CNG) ORIGINAL EQUIPMENT MANUFACTURER (OEM) VEHICLES AT FT. BLISS, TEXAS

INTERIM REPORT
TFLRF No. 303

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A technology demonstration program of dedicated compressed natural gas (CNG) original equipment manufacturer (OEM) vehicles was conducted at Ft. Bliss, Texas to demonstrate the use of CNG as an alternative fuel. The demonstration program at Ft. Bliss was the first Army initiative with CNG-fueled vehicles under the legislated Alternative Motor Fuels Act. This Department of Energy (DOE)-supported fleet demonstration consisted of 48 General Services Administration (GSA)-owned, Army-leased 1992 dedicated CNG General Motors (GM) 3/4-ton pickup trucks and four 1993 gasoline-powered Chevrolet 3/4-ton pickup trucks. The data that this demonstration would yield included overall engine performance, vehicle operation and maintenance, fuel economy, and assessment of exhaust emissions. As a result of this demonstration program, it was revealed that the CNG-powered pickups displayed erratic engine performance and increased unscheduled maintenance and fuel-related parts replacements. There were also noted decreases in fuel economy and exhaust emissions in the CNG-powered trucks. However, after retrofitting improved CNG conversion hardware, there were no apparent differences in vehicle operation and drivability between the CNG- and gasoline-powered trucks. The fleet demonstration was prematurely halted when GSA grounded the entire fleet of CNG trucks as a precautionary safety measure when two instances of CNG cylinder failures involving the 1992 GM 3/4-ton pickup trucks at locations other than Ft. Bliss were reported.

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EXECUTIVE SUMMARY

Problems and Objectives: The technology demonstration of dedicated compressed natural gas (CNG) original equipment manufacturer (OEM) vehicles at Ft. Bliss, Texas, was conducted as a result of Section 400-AA of the Alternative Motor Fuels Act (AMFA) of 1988, the Clean Air Act (CAA) Amendments of 1990, and the Energy Policy Act of 1992. The objectives of the program were to demonstrate the acceptability of alternative-fueled vehicles in a Department of Defense (DOD) U.S. Army activity in support of post, camp, and station operations; to quantify vehicle performance, fuel economy, engine performance and maintenance, and assessment of exhaust emissions; and to compare assessments and evaluations to a limited fleet of gasoline-fueled control vehicles.

Importance of Project: In a cooperative effort, the data generated from the Ft. Bliss CNG demonstration was shared with the Alternative Fuels Data Center. The center's function is an integral part of AMFA fleet demonstrations and is responsible for the unbiased reporting of alternative fuels evaluation results and identification of problem areas. Most importantly, the demonstration provided real-world utilization and performance data on OEM dedicated CNG-fueled vehicles.

Technical Approach: The fleet of General Services Administration (GSA)-owned, Army-leased CNG-fueled vehicles was placed under the direction of the Ft. Bliss Transportation Division. The vehicles were randomly assigned to the different services sections to be used in daily mission requirements. Designated drivers of the CNG vehicles were required to attend training classes that covered topics such as program background and objectives, CNG description and objectives, and data collection procedures and responsibilities.

Four gasoline-burning vehicles of the same type as the CNG vehicles were selected as control vehicles. The baseline data obtained from these vehicles would be used as a comparison to the performance, fuel economy, maintenance, and emissions evaluations of the CNG fleet.

Accomplishments: A total of 329,742 miles were accumulated during the program, of which 287,548 miles were obtained using CNG fuel. The CNG vehicles experienced severe drivability and performance problems at the onset of the program. It was not until PAS, Inc.--the company that converted the pickups for General Motors--retrofitted the vehicles with redesigned gaseous injectors that the problems were resolved. The limited range of the vehicles also became a problem at Ft. Bliss, Texas. Since several Ft. Bliss activities were past the range of the vehicles, vehicles were reassigned to circumvent the problem. Consequently, the CNG trucks were relegated to short, start-and-stop urban missions, affecting the accumulation of mileage. There was a noted decrease in fuel economy on the CNG vehicles when compared to the gasoline control vehicles; however, part of the difference lies in the duty cycles of the vehicles. There was also a noted decrease in exhaust emissions in the CNG-powered vehicles. The fleet demonstration was prematurely halted when two instances of CNG cylinder failures involving the 1992 GM pickup trucks occurred at locations other than Ft. Bliss.

Military Impact: This short-term demonstration program accumulated data and generated results that can be utilized in the decision-making process of assigning dedicated CNG vehicles to military post, camp, and station operations.

FOREWORD/ACKNOWLEDGMENTS

This work was performed by the U.S. Army TARDEC Fuels and Lubricants Research Facility (TFLRF) located at Southwest Research Institute (SwRI), San Antonio, Texas, during the period October 1992 through May 1994 under Contract No. DAAK70-92-C-0059. The work was funded by the U.S. Department of Energy (DOE) and administered by the U.S. Army Tank-Automotive and Armaments Command (TACOM), Mobility Technology Center-Belvoir (MTCB), Ft. Belvoir, Virginia. Mr. John Garbak (CE-332) served as the DOE project technical monitor, and Mr. T.C. Bowen (AMSTA-RBFF) served as the MTCB contracting officer's representative and project technical monitor.

The authors would like to acknowledge the assistance provided by Mr. Robert Galindo and Ms. Ursula Featherston, Transportation Branch, Transportation Division, Ft. Bliss, Texas, for their enthusiastic support throughout the program. Also, special mention is given to Mr. Bernard Jones, GSA Fleet Management Office, El Paso, Texas, for his contribution in the data gathering effort.

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LIST OF ACRONYMS

AFV	Alternative-Fueled Vehicle
AMFA	Alternative Motor Fuels Act
CAA	Clean Air Act
CARB	California Air Resources Board
CNG	Compressed Natural Gas
CO	Carbon Monoxide
DOD	Department of Defense
DOE	Department of Energy
EPA	Environmental Protection Agency
FTP	Federal Test Procedure
GM	General Motors (Corporation)
GSA	General Services Administration
GVW	Gross Vehicle Weight
HFET	Highway Fuel Economy Test
LDT	Light-Duty Truck
LEV	Low Emission Vehicle
MIR	Maximum Incremental Reactivity
MTCB	Mobility Technology Center-Belvoir
NIPER	National Institute for Petroleum and Energy Research
NMHC	Nonmethane Hydrocarbons
NMOG	Nonmethane Organic Gases
NOx	Oxides of Nitrogen
NREL	National Renewable Energy Laboratory
OEM	Original Equipment Manufacturer
RAF	Reactivity Adjustment Factor
SR	Specific Reactivity
SwRI	Southwest Research Institute
TACOM	U.S. Army Tank-Automotive and Armaments Command
TARDEC	U.S. Army Tank-Automotive Research, Development and Engineering Center
TFLRF	TARDEC Fuels and Lubricants Research Facility
THC	Total Hydrocarbons
TLEV	Transitional Low Emission Vehicle
TMP	Transportation Motor Pool
ULEV	Ultra Low Emission Vehicle

I. BACKGROUND

Section 400-AA of the Alternative Motor Fuels Act (AMFA) of 1988 (1)* established the Federal Light-Duty Vehicle Program. AMFA's aim is to incorporate alternative-fueled vehicles (AFVs) into government fleet operation and evaluate their performance. The Department of Energy (DOE) is responsible for implementing the AMFA with the assistance of other agencies.(2) The General Services Administration (GSA) is tasked to acquire the AFVs and assist in their placement within the federal fleet. Natural gas has demonstrated that it has potential as a cleaner burning fuel for motor vehicles than gasoline. Consequently, the possibility of introducing cleaner burning fuels in lieu of gasoline in automotive service has drawn increasing attention in the last decade. The reduction or elimination of some pollutant emissions, such as ozone-forming hydrocarbons, is a driving force behind the recently announced air pollution control strategies for the state of California and the U.S. government.(3)

II. INTRODUCTION

An interagency agreement (4) between DOE and the U.S. Army Tank-Automotive and Armaments Command (TACOM), Mobility Technology Center-Belvoir (MTCB), Ft. Belvoir, Virginia, was executed to provide for U.S. Army support of the AMFA of 1988, Public Law 100-494, prior to the initiation of a DOE-sponsored technology demonstration of dedicated General Motors (GM) 3/4-ton original equipment manufacturer (OEM) pickup trucks at Ft. Bliss, Texas. Ft. Bliss was chosen because of its location in El Paso, Texas--a nonattainment air quality area designated by the Environmental Protection Agency (EPA).

Liaison/coordination meetings with designated personnel from Ft. Bliss, the GSA Fleet Management Office, and Southern Union Gas Company in El Paso, Texas were conducted by a monitor from the U.S. Army TARDEC Fuels and Lubricants Research Facility (TFLRF) located at Southwest Research Institute (SwRI), San Antonio, Texas, to ensure a smooth implementation of the demonstration program.

* The underscored numbers in parentheses refer to the list of references at the end of this report.

The interagency agreement stipulated that the collection of fleet vehicle data be in accordance with a Data Protocol (5) and Data Collection Plan (6) provided by the National Renewable Energy Laboratory (NREL). A data transmission modem and appropriate software were procured to enable electronic transmission of the data to NREL.

III. PROGRAM OBJECTIVES

The objectives of the technology demonstration of dedicated compressed natural gas (CNG) OEM vehicles were as follows:

- to demonstrate the acceptability of dedicated alternative-fueled vehicles in support of the AMFA of 1988, Public Law 100-494, and in a Department of Defense (DOD) U.S. Army activity in support of post, camp, and station operations;

- to quantify vehicle performance, fuel economy, engine performance and maintenance, and assessment of exhaust emissions; and

- to compare assessments and evaluations to a limited fleet of control vehicles.

IV. FLEET DEMONSTRATION PROGRAM

Training classes were held for designated drivers of the CNG vehicles and for selected personnel at Ft. Bliss, Texas, prior to the start of the program. Topics covered included the following:

- Program background and objectives
- CNG description and precautions
- AFV description
- Program data collection objectives
- Data collection procedures and responsibilities.

The transportation division at Ft. Bliss assigned the CNG vehicles to the different sections and units in the same manner as the gasoline vehicles without regard to driving cycles and mission requirements. A procedure was initiated in which the operators were required to dispatch the vehicles on a weekly basis and turn in the previous week's operational information on the vehicle. The drivers' cards were consolidated at the Transportation Motor Pool (TMP) and mailed to TFLRF on a weekly basis. The data were then entered into a PARADOX database and electronically transmitted to the Alternative Fuels Data Center at NREL.

The GSA fleet operations office in El Paso, Texas, assumed the responsibility of providing maintenance data and tasking the maintenance contractor to obtain used oil samples on selected vehicles. The used oil samples were mailed to the National Institute for Petroleum and Energy Research (NIPER) for analysis. Monthly CNG samples from the refueling facility were obtained by TFLRF staff and also mailed to NIPER.

A meeting was held with GSA and Ft. Bliss staff to arrange the selection of five test vehicles and two control vehicles for emissions testing throughout the duration of the demonstration program. The selection of the vehicles was assigned to the Ft. Bliss transportation officer to minimize the impact that random selection of critical use vehicles would incur. The vehicles would be transported from El Paso to SwRI in San Antonio, Texas, for testing that would require a turnaround time of five working days. Testing would include the Federal Test Procedure (FTP) for regulated emissions and would be conducted at 4,000-, 10,000-, and 20,000-mile intervals.

The TFLRF monitor would visit El Paso and Ft. Bliss, Texas, on a monthly basis to conduct liaison visits with GSA and Ft. Bliss fleet managers, collect samples and usage/maintenance data, and solicit user comments on the CNG vehicles.

A. Fleet Vehicle Description

1. CNG Test Vehicles

The 48 GSA-owned, Army-leased vehicles used for the demonstration were 1992 GM dedicated CNG 3/4-ton pickup trucks with a gross vehicle weight (GVW) rating of 7,200 lbs. (illustrated in Fig. 1). The powertrain included a 5.7-L V8 engine coupled to an MD8/4L60 automatic transmission. All of the trucks were equipped with air conditioning, power brakes, and power steering. PAS, Inc. performed the CNG conversions for GM. Fuel components included two gaseous fuel throttle body injectors, pressure regulator, manual and electric fuel shut-off valves, fuel level transducer, and three underbody-mounted CNG fuel tanks with 11.2 equivalent gallons of capacity at a pressure of 3,600 psi. (Figure 2 illustrates the CNG vehicle modifications.) A few months into the demonstration, a bed-mounted CNG tank with an additional 10 equivalent gallons of capacity was installed on 24 of the trucks.

Figure 1. A 1992 CNG GM 3/4-ton test truck

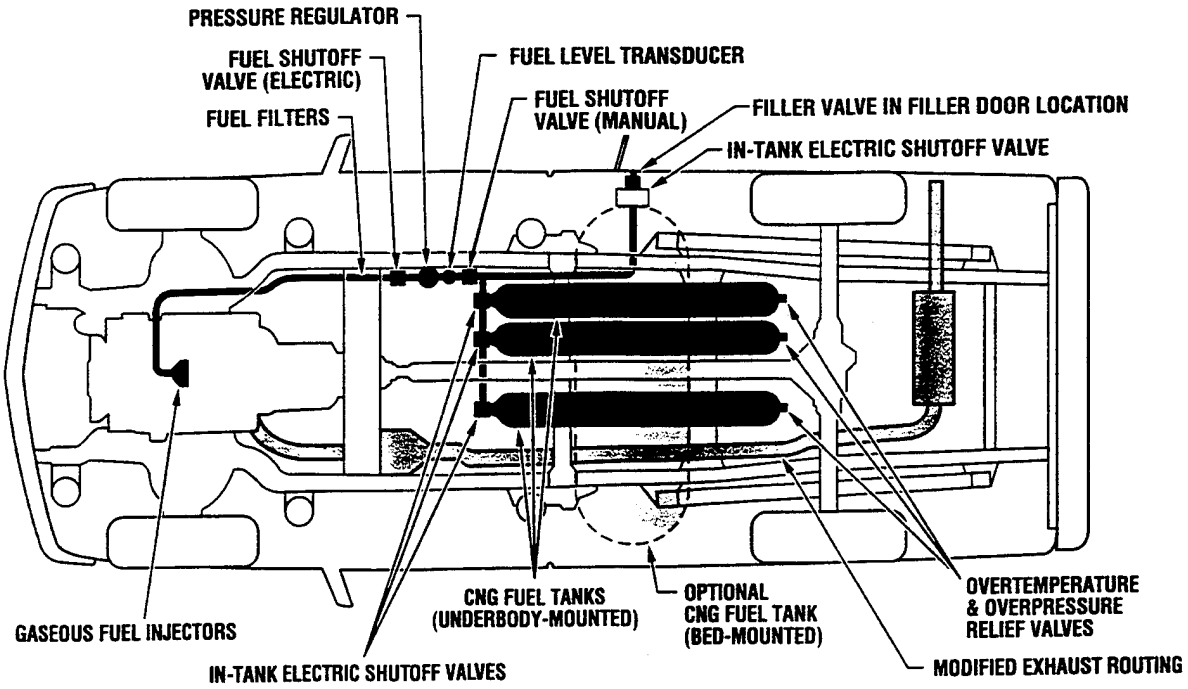


Figure 2. CNG vehicle modifications

2. Gasoline Control Vehicles

The control vehicles were not available at the start of the demonstration but were incorporated seven months into the program. The control vehicles were four 1993 gasoline-powered 3/4-ton pickup trucks (GVW = 7,200 lbs.) with a 5.0-L V8 engine coupled to an MD 8/4L60 automatic transmission. Like their test counterparts, each truck was equipped with air conditioning, power brakes, and power steering. The capacity of the fuel tank was 25 gallons.

It should be noted that while the control vehicles were equipped with a 5.0-L V8 engine and the test vehicles were equipped with a 5.7-L V8 engine, both engines have the same GM emissions certification rating. Environmental Protection Agency mileage specification report (7) for 1992 and 1993 2500 series light-duty trucks lists the city driving cycle mileage at 14 miles per gallon (mpg) for the 5.0-L and 5.7-L engines and the highway driving cycle mileage at 18 and 19 mpg, respectively.

TABLE 1 lists the characteristics of the test and control vehicles, including odometer reading and test start date.

TABLE 1. Description of Test and Control Vehicles

Test Vehicles

Vehicle Tag No.	Year	Make/Model	Engine Size	No. of Cyl.	Auto Trans	GVW*	Tire Size	Start of Test		Test Fuel
								Odometer	Date	
4267029	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	162	10/21/92	CNG
4267030	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	94	01/10/92	CNG
4267031	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	177	02/10/92	CNG
4267032	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	214	02/10/92	CNG
4267033	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	217	01/10/92	CNG
4267034	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	305	01/10/92	CNG
4267035	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	201	02/10/92	CNG
4267036	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	94	07/10/92	CNG
4267037	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	304	02/10/92	CNG
4267038	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	521	02/10/92	CNG
4267039	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	290	01/10/92	CNG
4267040	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	231	01/10/92	CNG
4267041	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	129	05/10/92	CNG
4267042	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	185	10/21/92	CNG
4267043	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	248	01/10/92	CNG
4267044	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	156	10/29/92	CNG
4267045	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	120	01/10/92	CNG
4267046	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	96	06/10/92	CNG
4267047	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	240	01/10/92	CNG
4267048	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	190	02/10/92	CNG
4267049	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	207	05/10/92	CNG
4267050	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	122	01/10/92	CNG
4267051	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	232	01/10/92	CNG
4267052	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	90	02/10/92	CNG
4267053	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	90	05/10/92	CNG
4267054	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	192	02/10/92	CNG
4267055	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	153	01/10/92	CNG
4267056	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	63	05/10/92	CNG

TABLE 1. Description of Test and Control Vehicles (Cont'd)

Vehicle Tag No.	Year	Make/Model	Engine Size	No. of Cyl.	Auto Trans	GVW*	Tire Size	Start of Test		Test Fuel
								Odometer	Date	
4267057	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	91	02/10/92	CNG
4267058	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	153	02/10/92	CNG
4267059	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	70	01/10/92	CNG
4267060	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	30	01/10/92	CNG
4267061	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	150	02/10/92	CNG
4267062	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	166	04/10/92	CNG
4267063	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	179	01/10/92	CNG
4267064	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	175	05/10/92	CNG
4267065	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	61	01/10/92	CNG
4267066	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	53	10/21/92	CNG
4267067	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	137	01/10/92	CNG
4267068	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	53	02/10/92	CNG
4267069	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	167	02/10/92	CNG
4267070	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	126	01/10/92	CNG
4267071	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	122	01/10/92	CNG
4267072	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	31	01/10/92	CNG
4267073	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	111	09/10/92	CNG
4267074	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	71	08/10/92	CNG
4267075	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	223	06/10/92	CNG
4267076	1992	GMC 2500	5.7L	8	MD8/4L60	7,200	245/75R16	198	01/10/92	CNG
					Control Vehicles					
4267092	1993	Chevrolet 2500	5.0L	8	MD8/4L60	7,200	225/75R16	900	07/19/93	Gasoline
4267094	1993	Chevrolet 2500	5.0L	8	MD8/4L60	7,200	225/75R16	1,036	07/20/93	Gasoline
4267095	1993	Chevrolet 2500	5.0L	8	MD8/4L60	7,200	225/75R16	1,013	07/21/93	Gasoline
4267096	1993	Chevrolet 2500	5.0L	8	MD8/4L60	7,200	225/75R16	1,084	07/26/93	Gasoline

* GVW = Gross Vehicle Weight

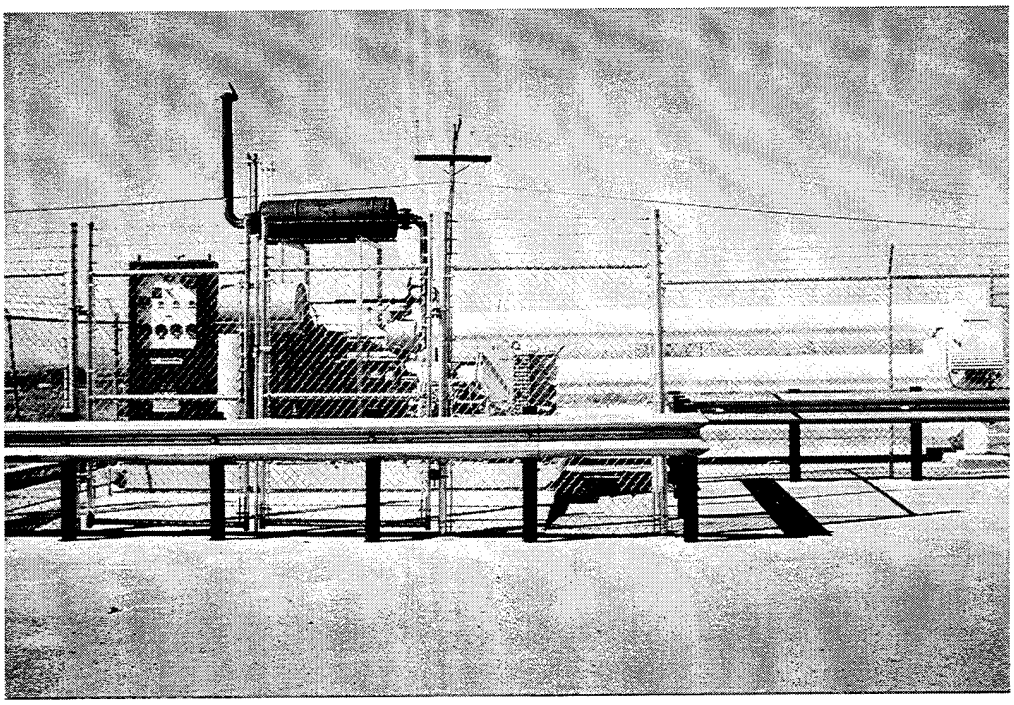
B. Refueling Stations

1. Compressed Natural Gas

The refueling station was a privately operated, card lock unattended facility located at Interstate 10 and Airway Boulevard in El Paso, Texas, approximately 5.5 miles from the CNG vehicle motor park at Ft. Bliss, Texas. Another refueling station was constructed adjacent to a main entrance gate at Ft. Bliss; however, due to major road construction in the area, the station was never utilized by the CNG fleet of trucks. Both stations were equipped with a 425 CFM compressor and a 100 equivalent gallon storage capacity and a two-nozzle dispenser with Sherex quick disconnects with a maximum fill pressure of 3,000 psi. Figure 3 shows the CNG dispensing station at Interstate 10 and Airway Boulevard in El Paso, Texas.

2. Gasoline

The gasoline refueling station at Ft. Bliss is a DOD-operated facility located at the TMP at Ft. Bliss, Texas. The station is a card lock automated facility, and fuel is delivered to underground storage tanks by a local refinery. It should be noted that the TMP at Ft. Bliss started receiving oxygenated gasoline in November 1991, one year before the Clean Air Act (CAA) stipulation for carbon monoxide nonattainment areas. TFLRF staff conducted a short-term fuel sampling program at Ft. Bliss, Texas. Findings can be found in Letter Report No. BFLRF-94-002.(8)



a. Compressor and storage tanks

b. Dispensing pump

Figure 3. The CNG dispensing station in El Paso, Texas

V. RESULTS OF FLEET DEMONSTRATION

A. Fleet Test Results

1. General

The forty-eight test vehicles accumulated a total of 287,548 miles from October 1992 through February 1994. The CNG fleet was grounded by GSA after two reported instances of CNG cylinder failures at locations other than Ft. Bliss, Texas, involving the 1992 GM 3/4-ton pickup, which resulted in injury to the vehicle operators. GM subsequently recalled all the CNG vehicles converted by PAS, Inc. The four control vehicles accumulated 42,194 miles from July 1993 through May 1994. As stated previously, the control vehicles were not brought into the demonstration program until seven months after program commencement; therefore, the data gathering effort in these vehicles was extended through May 1994.

2. Fuel Economy

A summary of the fuel economy data for test and control vehicles is presented in TABLES 2 and 3. Individual monthly mileage and fuel usage summaries for each of the 48 test vehicles and 4 control vehicles are included in Appendix A. TABLES 2 and 3 show the fuel economy of the vehicles operating on CNG to range from 9.6 to 13.6 mpg, while the control vehicles ranged from 13.6 to 15.5 mpg. A graphical presentation of the data, including comparison of FTP fuel economy, is shown in Fig. 4. This equates to an approximately 25 percent decrease in fuel economy for the CNG vehicles. Since natural gas provides more energy per pound than does gasoline, one would expect increased fuel economy or at minimum, fuel economy equal to that of gasoline. However, in order to realize this increased economy, the engine design must be optimized for natural gas.(9) The PAS-converted GM engines used for this demonstration were production line gasoline spark ignition engines without internal modifications. In addition, a large part of the difference in fuel economy between the test and control vehicles can be attributed to the duty cycles of the vehicles. The CNG test vehicles, because of their limited

TABLE 2. Summary of Test Vehicle Data Miles and Equivalent Gallon Fuel Consumption

Test Vehicles

Vehicle Tag No.	Miles	Gal.	Gal./Mile	Miles/Gal.
4267029	4,850	477.2	0.098	10.2
4267030	3,728	353.7	0.095	10.5
4267031	1,567	142.7	0.091	11.0
4267032	4,259	382.2	0.090	11.1
4267033	3,202	264.3	0.083	12.1
4267034	2,972	271.3	0.091	11.0
4267035	4,500	387.3	0.086	11.6
4267036	5,768	450.0	0.078	12.8
4267037	5,990	441.9	0.074	13.6
4267038	5,107	437.1	0.086	11.9
4267039	10,287	841.1	0.082	12.2
4267040	8,112	826.8	0.102	9.8
4267041	5,415	496.9	0.092	11.0
4267042	2,054	203.8	0.099	10.1
4267043	11,111	870.9	0.078	12.6
4267044	2,234	210.7	0.094	10.6
4267045	2,102	181.5	0.086	11.6
4267046	4,088	354.1	0.087	11.8
4267047	4,806	373.3	0.078	12.9
4267048	7,624	664.0	0.087	11.5
4267049	6,535	557.9	0.085	11.7
4267050	4,663	403.6	0.087	11.6
4267051	7,713	645.3	0.084	12.0
4267052	3,830	398.1	0.104	9.6
4267053	3,779	372.8	0.099	10.1
4267054	6,741	643.4	0.095	10.5
4267055	4,722	482.3	0.102	9.8
4267056	7,511	710.6	0.095	10.6
4267057	9,002	732.4	0.081	12.3
4267058	5,906	571.8	0.097	10.3
4267059	7,470	572.6	0.077	13.0
4267060	5,005	457.6	0.091	10.9
4267061	9,119	781.6	0.086	11.7
4267062	8,183	736.5	0.090	11.1
4267063	8,498	711.2	0.084	11.9
4267064	2,596	241.5	0.093	10.7
4267065	4,468	413.1	0.092	10.8
4267066	10,066	880.1	0.087	11.4
4267067	9,597	865.6	0.090	11.1
4267068	5,889	570.0	0.097	10.3
4267069	15,771	1,330.9	0.084	11.8
4267070	6,218	543.3	0.087	11.4
4267071	5,903	492.3	0.083	12.0
4267072	5,242	443.7	0.085	11.8
4267073	4,645	398.1	0.086	11.7
4267074	5,365	460.5	0.086	11.7
4267075	5,694	540.8	0.095	10.5
4267076	7,384	665.5	0.090	11.1
Average	5,985	526.1	0.089	11.3
Std Dev	2,717	227.1	0.007	0.9

TABLE 3. Summary of Control Vehicle Data Miles and Fuel Consumption

Control Vehicles

Vehicle Tag No.	Miles	Gal.	Gal./Mile	Miles/Gal.
4267092	10,380	669.0	0.064	15.5
4267094	11,041	761.0	0.069	14.5
4267095	10,484	770.7	0.074	13.6
4267096	10,289	755.0	0.073	13.6
Average	10,549	738.9	0.070	14.3
Std Dev	338	47.1	0.005	0.9

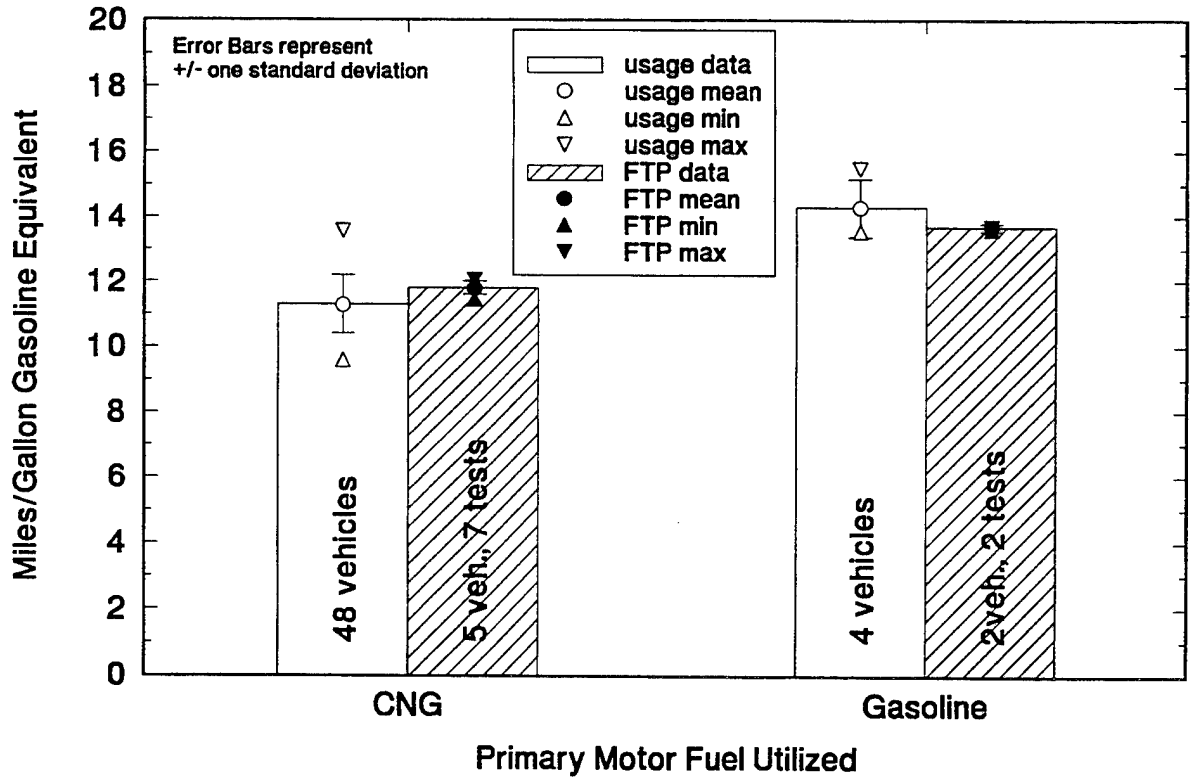


Figure 4. CNG vs. gasoline comparing usage data and FTP data

range, were used exclusively for short, start-and-stop urban missions. Conversely, the control vehicles were operated in urban and rural missions. This is supported by the fact that the average miles per test vehicle in 14 months of operation was 5,991, while the average miles per control vehicle in 10 months of operation was 10,549. Figure 5 shows the average vehicle mileage accumulation.

3. Fuel System Component Replacement

Throughout the demonstration program, the vehicles were under manufacturer's warranty. Unscheduled repairs on the test and control vehicles were performed by an authorized GM dealership in El Paso, Texas. From the onset of the program, the CNG trucks were beset with fuel system failures. Especially troublesome were the injector and throttle body assemblies. During the early months of the demonstration, as many as 50 percent of the vehicles were out of service due to faulty gas injectors. The average downtime for fuel system repairs was 21 days.

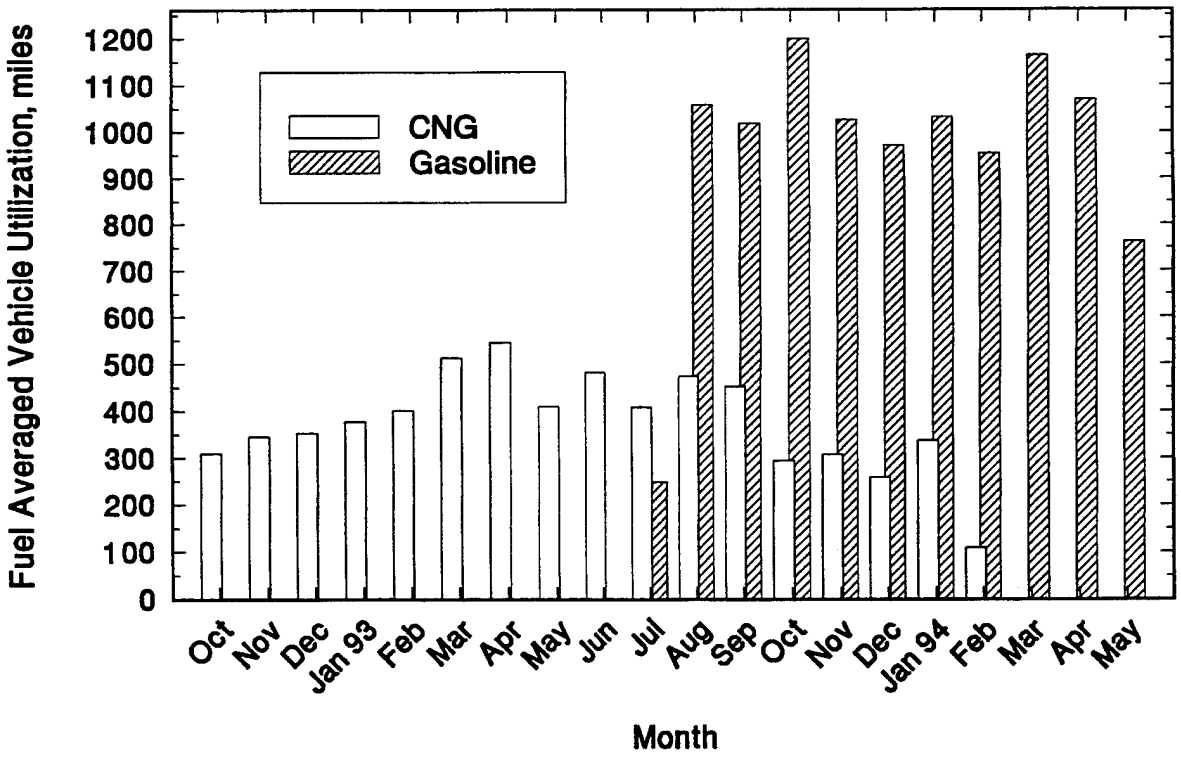


Figure 5. Ft. Bliss monthly average vehicle mileage accumulation

The limited availability of replacement parts was the primary reason for the excessive downtime. Four months after the start of the program, PAS, Inc. retrofitted the 48 trucks with redesigned injector assemblies. The problems abated soon after the retrofit. TABLE 4 summarizes the replacement of fuel system components. It should be noted that 90 percent of injector set replacements were performed during the first four months of the demonstration. Ten percent of the fleet required only one injector set replacement, 35 percent required two replacements, 35 percent accounted for three replacements, and 19 percent required four replacements. Also, quite often in conjunction with injector set replacements, 88 percent of the fleet required replacement of the throttle body assembly. There were no fuel system components replaced on the control vehicles.

4. Drivability

The drivability of the fleet vehicles was assessed by requiring the drivers to rate the degree of severity of eight performance problem variables listed on the daily log sheet. An "A" signified mildly annoying, while "T" signified very troublesome. TABLE 5 presents a monthly performance problem summary, while TABLE 6 summarizes the drivers' responses to performance problems noted in the CNG vehicles. In TABLE 5, beginning in March, there is a sharp decrease in the number of performance problems reported. This coincides with the redesigned injector retrofit covered in the previous section. TABLE 6 shows that "Idle Quality" and "Hesitation" account for 47 percent of the performance problems reported. "Hard to Start" and "Stalled After Starting" make up 34 percent of the total number of occurrences, while "Stalled in Traffic," "Lack of Power," "Pinging," and "Check Engine Light" constitute 19 percent. Figures 6 through 9 graphically present the frequency of performance problem reports and the number of vehicles reporting difficulties for the eight performance problem variables studied. In contrast, there were no performance problems reported on the control vehicles. The fuel system failures experienced by 90 percent of the CNG fleet vehicles in the beginning of the program more than likely set the standard for reporting performance problems by the operators. This is evident in that 78 percent of the performance problems reported occurred between December 1992 and March 1993, and only 22 percent occurred during April 1993 and March

TABLE 4. Fuel System Component Replacement Summary

GSA Tag No.	Fuel Injector Assembly	Throttle Body Assembly	Fuel Regulator Assembly	Fuel Filter Assembly	Fuel Shut-Off Solenoid	Fuel Sending Unit
4267029	2	1	1			
4267030	3	1	1			
4267031	3	1		1		
4267032	3	1		1		
4267033	2		1	1		
4267034	2	2				
4267035	2	1			1	
4267036	2	1				1
4267037	3	1		1		
4267038	3	1		1		
4267039	1	1		1		
4267040	3	1		2		
4267041	2			1		
4267042	4	2		1		
4267043	4	2		1		
4267044	3	2		1		
4267045	3	3		2		
4267046	3	2				
4267047	3	2		2		
4267048	3	2				
4267049	2	1				
4267050	4	2	1			
4267051	1	1	1			
4267052	2			1		
4267053	2	1			1	
4267054	4	2	1	1		
4267055	2	1	1			
4267056	3	1		1		
4267057	2	1				
4267058	3	2		1		
4267059	1	2				
4267060	4	2		1		
4267061	1		1			
4267062	1					
4267063	4	3				
4267064	4	1		1		
4267065	2	1				
4267066	3	1		1		
4267067	2	1				
4267068	2	1	1			
4267069	2	1	1	1		1
4267070	3	2		1		
4267071	3	2		1		
4267072	4			1		
4267073	2	1	1			
4267074	2	1				
4267075	4	2		2		
4267076	3	2	1	1		

TABLE 5. CNG Fleet Monthly Performance Problem Summary — December 1992 Through January 1994

Performance Problem	1992		1993																						1994	
	Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		Jan	
	A*	T	A	T	A	T	A	T	A	T	A	T	A	T	A	T	A	T	A	T	A	T	A	T	A	T	A	T
Hard to Start	53	41	33	30	59	24	55	22	18	2	11	0	17	2	3	0	14	0	9	0	10	1	25	0	13	0	29	1
	16	**9**	**5**	**11**	**13**	**7**	**11**	**7**	**4**	**2**	**2**	**0**	**3**	**1**	**1**	**0**	**2**	**0**	**1**	**0**	**2**	**1**	**5**	**0**	**3**	**0**	**5**	**1**
Stalled After Starting	67	47	32	46	62	31	61	22	17	3	10	0	15	0	3	0	12	0	13	0	7	0	19	0	8	1	18	0
	16	**9**	**11**	**6**	**11**	**7**	**7**	**4**	**3**	**1**	**2**	**0**	**3**	**0**	**1**	**0**	**2**	**0**	**4**	**0**	**2**	**0**	**2**	**0**	**3**	**1**	**1**	**0**
Stalled in Traffic	33	26	11	21	29	6	22	2	4	1	0	0	1	0	0	0	2	0	2	0	2	0	17	0	6	0	19	0
	11	**6**	**7**	**4**	**7**	**4**	**4**	**2**	**1**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**2**	**0**	**1**	**0**	**1**	**0**	**2**	**0**	**3**	**0**	**1**	**0**
Idle Quality	178	54	94	46	121	28	84	24	56	20	13	0	7	0	18	0	17	0	5	0	2	0	18	0	14	0	10	5
	24	**12**	**13**	**6**	**20**	**7**	**13**	**2**	**8**	**2**	**4**	**0**	**4**	**0**	**1**	**0**	**5**	**0**	**1**	**0**	**1**	**0**	**2**	**0**	**3**	**0**	**1**	**1**
Hesitation/Coughing	120	46	117	20	105	28	42	7	7	1	0	0	1	0	3	0	5	0	0	0	2	0	15	0	4	0	9	0
	23	**10**	**15**	**5**	**15**	**6**	**8**	**3**	**3**	**1**	**0**	**0**	**1**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**3**	**0**	**1**	**0**	**1**	**0**
Lack of Power	42	17	28	18	50	9	15	0	7	0	0	0	1	0	0	0	0	0	0	0	2	0	10	0	6	0	3	0
	16	**4**	**9**	**6**	**10**	**3**	**6**	**0**	**3**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**2**	**0**	**1**	**0**	**1**	**0**
Pinging	2	6	11	4	17	0	6	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	3	0	0	0	1	0
	1	**1**	**3**	**1**	**2**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**2**	**0**	**0**	**0**	**1**	**0**
Check Engine Light	24	12	9	10	9	3	0	0	11	3	4	0	2	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0
	4	**1**	**4**	**1**	**2**	**2**	**0**	**0**	**3**	**1**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**

* A = Mildly annoying
T = Very troublesome
Upper No. = Total number of occurrences
Bold Lower No. = Number of vehicles reporting problem

TABLE 6. CNG Fleet Performance Problem Summary

Performance Problem	Total Number of Occurrences A*	T**
Hard to Start	349	123
Stalled After Starting	344	150
Stalled in Traffic	148	56
Idle Quality	637	177
Hesitation/Coughing	430	102
Lack of Power	164	44
Pinging	43	10
Check Engine Light	62	28

* A = Mildly annoying
** T = Very troublesome

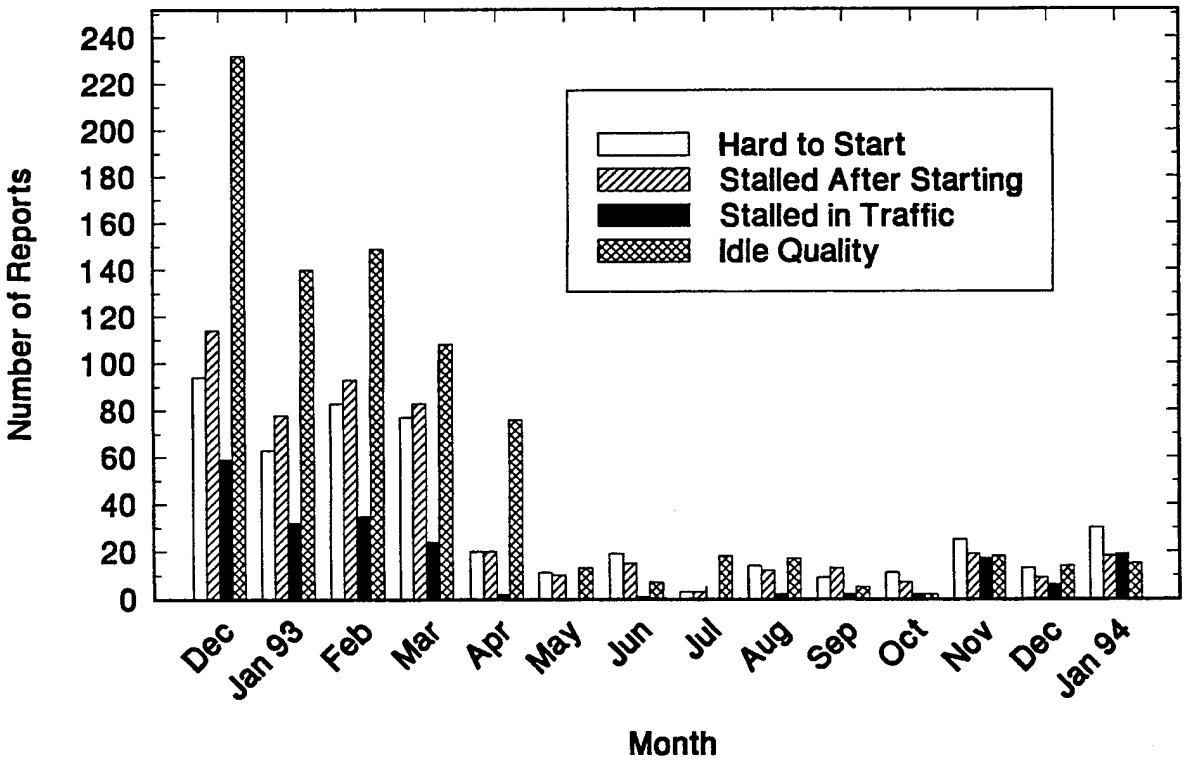


Figure 6. Frequency of reporting some degree of performance problem

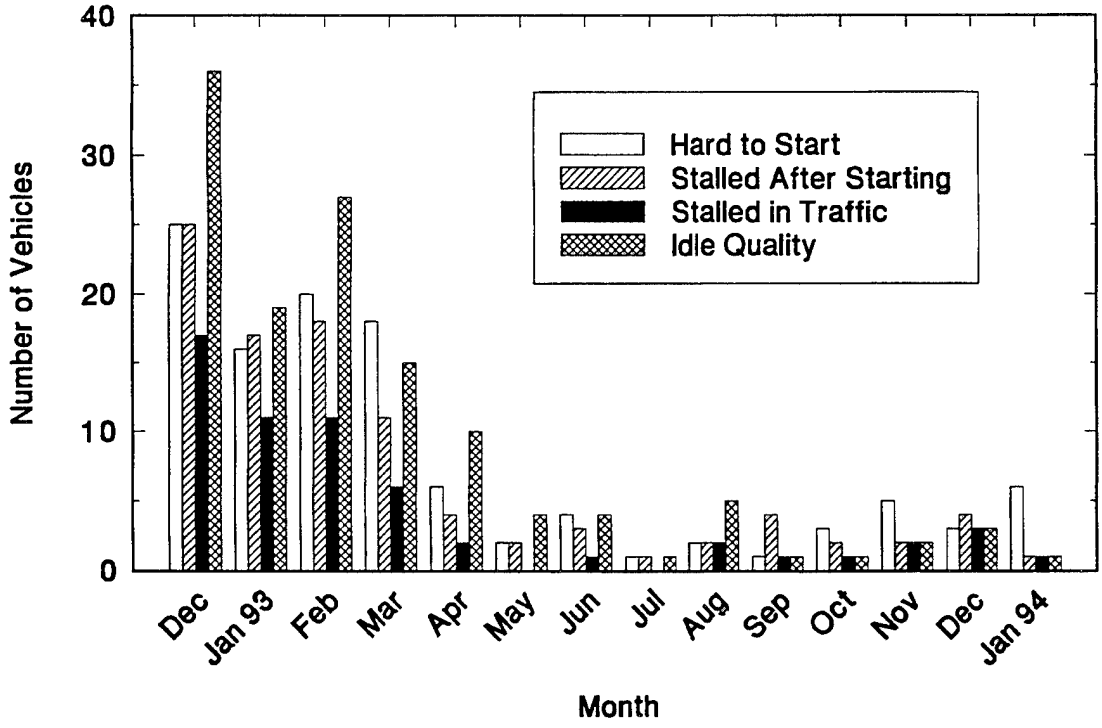


Figure 7. Vehicles reporting some degree of performance problem

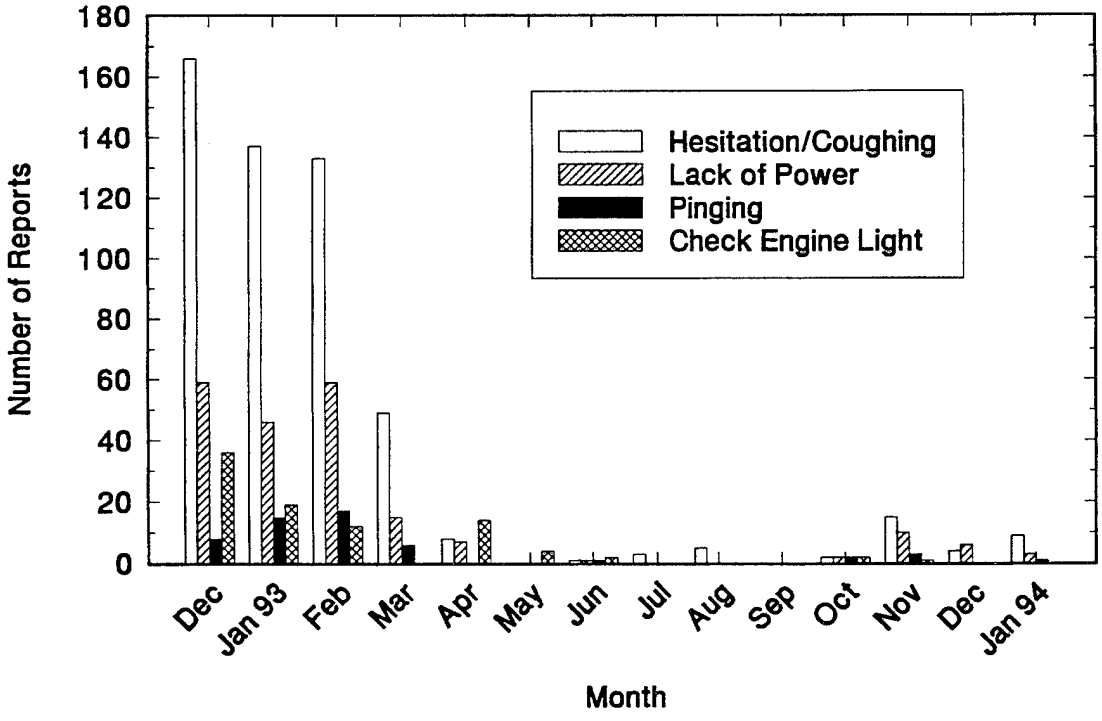


Figure 8. Frequency of reporting some degree of performance problem

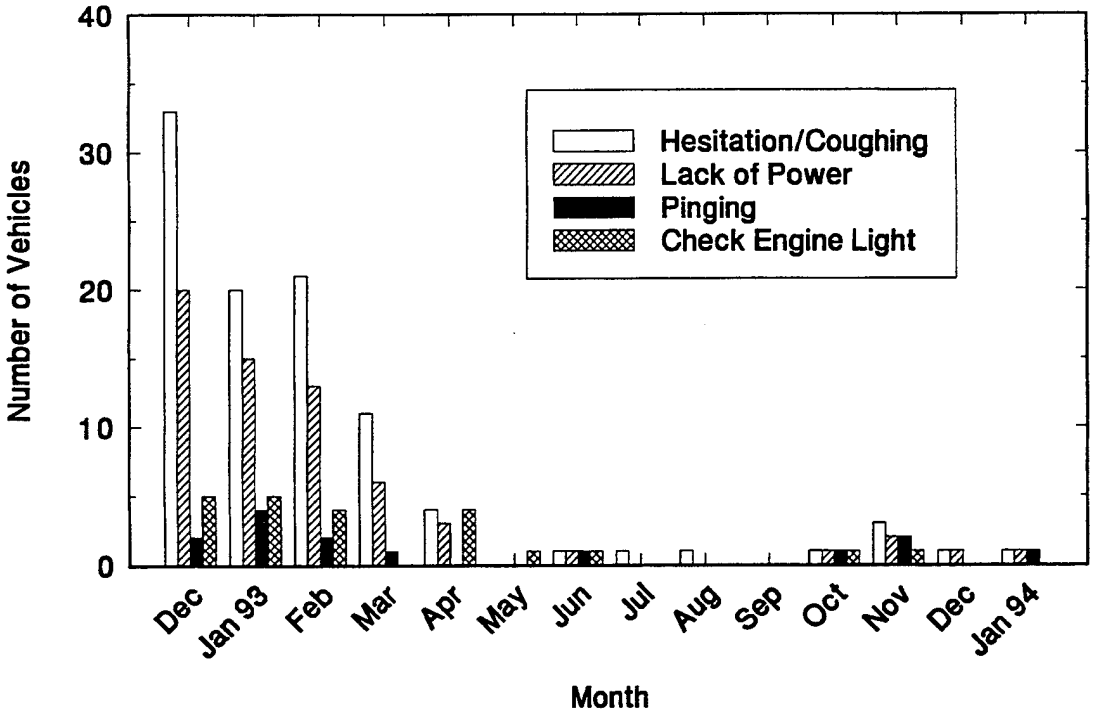


Figure 9. Vehicles reporting some degree of performance problem

1994. Also, the performance problems reported after April 1993 occurred on only 6 percent of the CNG vehicles. There were several instances in which the operator would continue to report a fault with the vehicle; however, when the vehicle was inspected, all systems were normal. This leads one to believe that a few of the operators were perhaps overly critical of their vehicle's performance and reported conceived rather than actual performance problems. User comments were solicited on every visit to the fleet site. Once the initial problems were solved, comments were favorable on the drivability and operability of the CNG vehicles.

5. Fuel Quality

CNG fuel samples were obtained from the fueling site on a monthly basis and shipped to NIPER for compound analyses. TABLE 7 presents the results of all samples obtained from El Paso, Texas. Methane constituted 93 percent of the gas composition, while constituents such as ethane, propane, nitrogen, and carbon dioxide made up the remaining 7 percent. All of the samples from El Paso conformed to the typical volumetric and mass base composition of natural gas.(10) Also, notable is the lack of seasonal variance of the gas composition for the period shown.

TABLE 7. Analysis of CNG Samples From El Paso, Texas by NIPER

Sample Date	Methane Mole %	Ethane Mole %	Propane Mole %	i-Butane Mole %	n-Butane Mole %	i-Pentane Mole %	n-Pentane Mole %	Hexane Mole %	Oxygen Mole %	Nitrogen Mole %	Carbon Dioxide Mole %	Gross Heating Value, Btu/cu. ft
02/25/93	93.80	3.14	0.58	0.06	0.11	0.04	0.04	0.06	0.01	1.72	0.46	1028
03/26/93	92.57	3.29	0.59	0.07	0.11	0.03	0.03	0.10	0.00	2.57	0.64	1021
04/29/93	93.50	3.21	0.62	0.07	0.12	0.04	0.04	0.10	0.02	1.64	0.65	1030
06/26/93	93.70	3.05	0.54	0.05	0.09	0.03	0.03	0.10	0.02	1.74	0.66	1025
07/30/93	93.59	3.00	0.55	0.07	0.12	0.04	0.04	0.12	0.02	1.85	0.65	1026
09/29/93	93.51	3.17	0.65	0.09	0.14	0.04	0.04	0.07	0.01	1.68	0.61	1030
10/22/93	93.97	2.21	0.52	0.06	0.09	0.03	0.03	0.10	0.02	2.14	0.84	1034
11/16/93	93.35	3.42	0.69	0.07	0.08	0.02	0.02	0.03	0.02	1.70	0.59	1032
12/02/93	93.45	3.48	0.63	0.05	0.06	0.02	0.02	0.03	0.01	1.51	0.75	1019
Average	93.49	3.11	0.60	0.07	0.10	0.03	0.03	0.08	0.01	1.83	0.63	1027

6. Used Oil Analysis

Used oil samples were obtained from selected vehicles and shipped to NIPER for analysis. Results of the analysis were not made available to TFLRF. In the beginning of the program, it was deemed advantageous to perform oxidation and nitration analysis by infrared spectroscopy on the used oil from the CNG vehicles for two reasons: 1) it had been reported that some commercial oils appeared deficient in oxidation and nitration protection, and 2) oxidation and nitration analysis were not included in NIPER's analysis protocol. After performing analyses on two batches of samples, however, the program was suspended when it was concluded that the analysis results would not yield the desired information. This was because oil changes were performed on the vehicles at 5,000-mile intervals or six months (whichever came first), and the vehicles, due to their limited range with CNG, were not accumulating sufficient miles to quantify changes on oil degradation from one analysis to the other. In addition, the infrared spectroscopy method requires a known baseline oil for comparison, and different brands and formulations of oils were being used.

B. Emissions Testing

1. General

The objective of testing the exhaust and evaporative emissions was to provide a method to compare emissions from the CNG and gasoline-powered test and control vehicles.

Five test vehicles and two control vehicles were selected for emissions testing at 4,000 miles and then at 10,000 miles. After the second evaluation, the testing would be conducted at 10,000-mile intervals or once per year. The testing was conducted by the Department of Emissions Research at Southwest Research Institute in San Antonio, Texas (an EPA-certified emissions testing laboratory). The vehicles were tested utilizing the FTP schedule for light-duty vehicles.(11)

2. Regulated Emissions and Highway Fuel Economy Test Results

TABLE 8 is a summary listing of the FTP results for regulated emissions of total hydrocarbons (THC), nonmethane hydrocarbons (NMHC), carbon monoxide (CO), oxides of nitrogen (NOx), and nonmethane organic gases (NMOG) for light-duty trucks (LDT). The EPA and California Air Resources Board (CARB) limits for emissions are given in g/mile; therefore, values are listed in consistent units for easy comparison. Emissions laboratory raw data and speciated emissions results are contained in Appendices B through F.

a. CNG Emissions

The averaged value of 1.61 g/mile for THC of all CNG vehicles shown in TABLE 8 is in excess of the Federal standard of 0.80 g/mile listed in TABLE 9. However, the NMHC measurements for CNG LDTs were well below the Federal and CARB limits of 0.32 and 0.50 g/mile, respectively. The five trucks, including the two retested at the 10,000-mile interval, emitted an average of 0.06 g/mile NMHC, far below the 1994 proposed Federal limit of 0.32 g/mile. The trucks (excluding one) met all California standards except the Ultra Low Emission Vehicle (ULEV) NMOG standard.

Carbon monoxide and NOx show considerable variance from one vehicle to another. The CO Federal limit of 10.0 g/mile was exceeded by only two of the five trucks tested. The remaining three trucks, however, were below the California standard of 9.0 g/mile. Oxides of nitrogen emitted by all of the vehicles tested were well below the 1991-1993 Federal standard of 1.7 g/mile. In fact, all but one of the trucks were below the California standard. The NOx emission rates of two trucks are significantly lower than the Low Emission Vehicle (LEV) and ULEV levels of 0.4 g/mile.

TABLE 8. FTP Regulated Emissions and Fuel Economy Test Results

						10K Retest				
Test Fuel	CNG	CNG	CNG	CNG	CNG	CNG	CNG		Gasoline	Gasoline
Vehicle No.	67043	67051	67047	67057	67059	67043	67051		70895	70896
Test Date	03/03/93	03/30/93	05/05/93	08/04/93	10/07/93	01/25/94	01/18/94		10/08/93	01/25/94
Vehicle Miles	5,218	4,328	4,231	5,646	6,196	11,225	7,847		3,414	7,393
Exhaust Emissions								Average		
THC, g/mile	1.90	1.51	1.17	1.59	1.71	1.85	1.57	1.61	0.42	0.45
NMHC, g/mile	0.04	0.02	0.03	0.05	0.05	0.05	0.05	0.04	N/A*	N/A
CO, g/mile	12.92	10.84	6.98	8.34	8.96	10.79	10.27	9.87	4.33	4.84
NOx, g/mile	0.55	0.22	0.43	0.05	0.71	0.57	0.41	0.42	1.37	1.51
NMOG, g/mile	0.105	0.076	0.061	0.073	0.078	0.081	0.076	0.785	0.378	0.425
CH4, g/mile	1.86	1.50	1.14	1.54	1.67	1.80	1.50	1.57	N/A	N/A
Fuel economy, mpg	11.97	11.49	11.79	11.62	11.95	12.07	11.79	11.81	13.72	13.64

* N/A = Not applicable

TABLE 9. Federal and California Emission Standards Applicable to Light-Duty Trucks

Standards	Year	g/mile THC	g/mile* CO	g/mile* NOx
Federal (EPA)	1991 - 1992 1994	0.80	10.0	1.7
	1994**	0.32†	4.4	0.7
California (CARB)	1989 - 1994 1996	0.50‡	9.0	0.7
	TLEV	0.16§	4.4	0.7
	LEV	0.10§	4.4	0.4
	ULEV	0.05§	2.2	0.4

* FTP, 80,450-km durability basis. To convert g/mile to g/km, multiply by 0.621.
** Proposed for dedicated CNG LDT
† NMHC
‡ NMHC or NMOG
§ NMOG

b. Gasoline Emissions

Total hydrocarbons test results for the trucks operated on gasoline are listed in the last two columns in TABLE 8. When these results are compared to the federal hydrocarbon limit of 0.80 g/mile, it is evident that both vehicles were well below the EPA standard. However, the results far exceeded the averaged 0.05 g/mile of NMHC emitted by the CNG trucks. Carbon monoxide emissions of 4.33 and 4.84, are well below the EPA and CARB standards, respectively, and approximate the 4.4 g/mile for Transitional Low Emission Vehicle (TLEV) and LEV standards.

Emissions of NOx, however, were just under the EPA limit of 1.7 g/mile but exceeded the CARB limit of 0.7 g/mile. The gasoline trucks had a 268 percent increase in NOx g/mile when compared to the CNG trucks. The following items should be noted: 1) the gasoline control trucks were 49-state emission vehicles, while the CNG trucks were converted to meet California

tier 0, Federal tier 0+ emission levels; and 2) FTP emission tests were performed utilizing a reference gasoline and not oxygenated gasoline, which was used in the El Paso, Texas area.

TABLE 10 compares exhaust emissions of two CNG trucks tested in March 1993 and again in January 1994. The averaged results illustrate that the only substantial increase with time and mileage occurred in the level of NMHC emissions. However, even with the 133 percent difference, the NMHC level was considerably lower than the 1994 Federal and California standards of 0.32 and 0.50 g/mile. Also, the level of NMOG of these two vehicles was below the CARB LEV and TLEV requirement of 0.10 and 0.16, respectively.

TABLE 10. FTP Regulated Emissions and Fuel Economy Test Results of Two CNG Trucks Tested at 4,000- and 10,000-Mile Intervals

	Test 1 (4,000 miles)			Test 2 (10,000 miles)		
Test Fuel	CNG	CNG		CNG	CNG	
Vehicle No.	67043	67051		67043	67051	
Test Date	03/03/93	03/03/93		01/25/94	01/25/94	
Exhaust Emissions			Average			Average
THC, g/mile	1.90	1.51	1.71	1.85	1.57	1.71
NMHC, g/mile	0.04	0.02	0.03	0.05	0.08	0.07
CO, g/mile	12.92	10.84	11.88	10.79	13.05	11.92
NOx, g/mile	0.55	0.22	0.39	0.57	0.32	0.45
NMOG, g/mile	0.11	0.08	0.10	0.08	0.08	0.08
Fuel economy, mpg	11.97	11.49	11.73	12.07	11.68	11.88

C. Regulated FTP and Highway Fuel Economy Test Results

The average of the FTP and Highway Fuel Economy Test (HFET) results show a 15 and 11 percent decrease in fuel economy, respectively, for the CNG-powered vehicles when compared to the gasoline-powered vehicles. In a study conducted at SwRI (12) on a CNG dedicated GM 3/4-ton pickup truck converted to operate on gasoline as well, the FTP fuel economy results on CNG were within 5 percent of the results obtained on the CNG trucks from Ft. Bliss. TABLE 11 presents the highway fuel economy test results of four CNG and two gasoline-powered trucks. Figure 10 depicts comparison of usage, FTP, and HFET fuel economy results.

TABLE 11. Highway Fuel Economy Test Results

Test Fuel	CNG	CNG	CNG	CNG	Gasoline	Gasoline
Vehicle No.	67047	67057	67059	67043	70895	70896
Test Date	05/05/93	08/04/93	10/07/93	01/25/94	10/08/93	01/25/93
Vehicle Miles	4,242	5,657	6,207	11,278	3,425	7,435
Exhaust Emissions						
THC, g/mile	0.89	1.28	0.96	0.95	0.03	0.03
NMHC, g/mile	0.06	0.05	0.01	0.02	N/A*	N/A
CO, g/mile	10.23	11.34	4.94	7.58	0.33	0.75
NOx, g/mile	0.40	0.38	0.88	0.34	0.74	1.26
NMOG, g/mile	0.04	0.05	0.04	0.02	0.02	0.02
CH4, g/mile	0.84	1.23	0.95	0.92	N/A	N/A
Fuel economy, mpg	17.81	17.33	18.21	18.78	20.40	19.66

* N/A = Not applicable

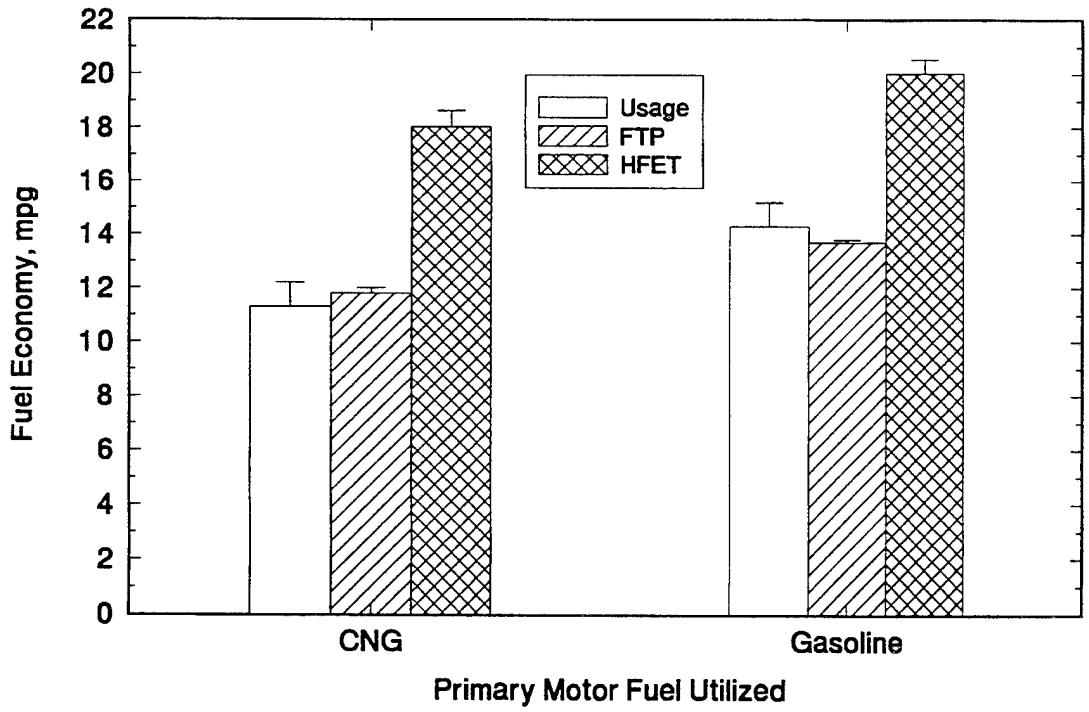


Figure 10. Ft. Bliss CNG and control vehicle fleet fuel economy

D. Speciated Emissions

The speciated unburned hydrocarbon FTP exhaust emissions for five CNG vehicles and one gasoline control vehicle are tabulated in Appendix F. The compounds speciated followed the NREL data collection guidelines (5) for the fuel each vehicle utilized. The results of the speciation were used to calculate the ozone-forming potential for each vehicle and fuel. The potential ozone formed was calculated using Maximum Incremental Reactivity (MIR) factors for the Los Angeles air basin model published by the Mobile Sources Division, California Air Resources Board.(13) Figure 11 shows the total potential grams of ozone formed per mile for each vehicle/fuel, accounting for potential ozone formed from methane and NMOG emissions.

Approximately 96 percent of the potential ozone formed by CNG is due to ethylene (50.1 percent), methane (16.6 percent), formaldehyde (14.4 percent), ethane (8.2 percent), propylene (4.7 percent), and propane (2 percent) in the exhaust. Likewise, only 43.5 percent of the

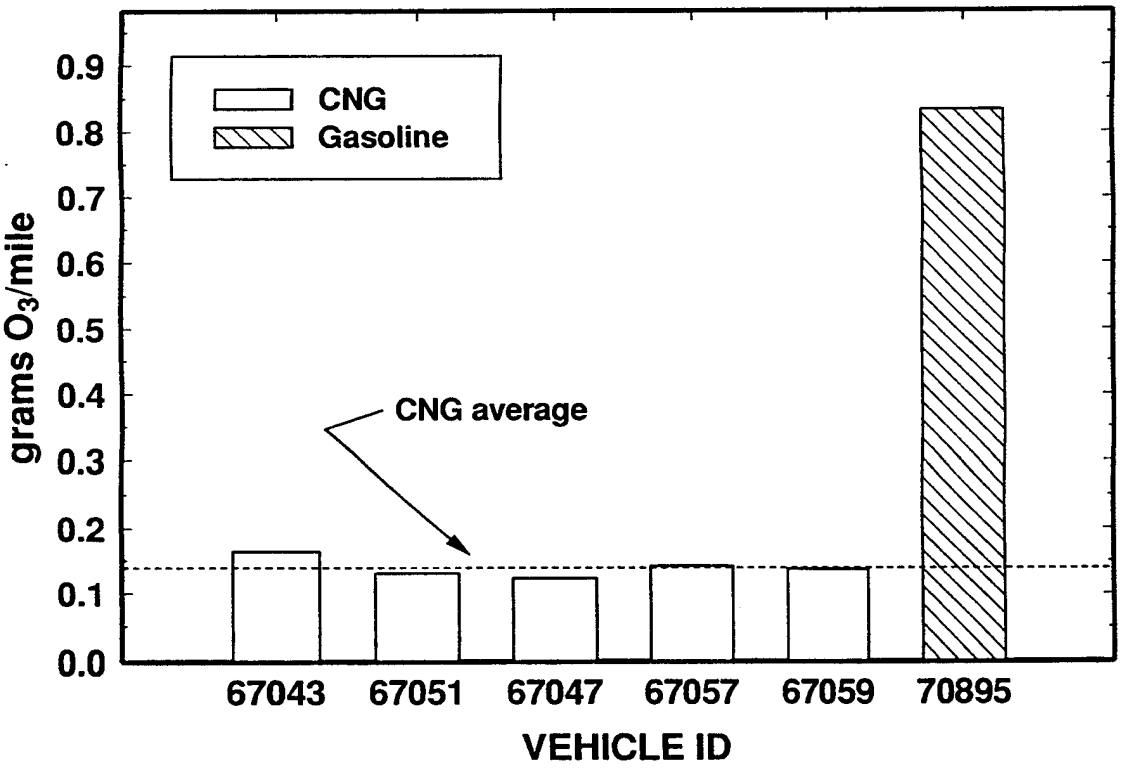


Figure 11. Estimated ozone formation from unburned hydrocarbon speciation

potential ozone formed by gasoline is attributed to ethylene (19.6 percent), methane (0.08 percent), formaldehyde (5.2 percent), ethane (0.16 percent), propylene (18.4 percent), and propane (0.03 percent). The balance of potential ozone formed by the gasoline vehicle is from higher molecular weight hydrocarbons containing double and triple bonds, with toluene (23.6 percent) being the largest contributor.

Figure 12 shows the average CNG vehicle and gasoline vehicle total potential ozone formation and potential ozone formed only from NMOG constituents. The total potential ozone includes the contribution of the methane in the exhaust. Even though methane has a very low MIR (0.0148 gO_3/g versus ethylene at 7.29 gO_3/g), the substantial mass of methane in CNG exhaust makes methane a major contributor to CNG vehicle ozone-forming potential. The bar representing the NMOG-formed potential ozone in Fig. 12 reveals the ozone-forming potential of the CNG vehicle exhaust when debited for the contribution of the methane.

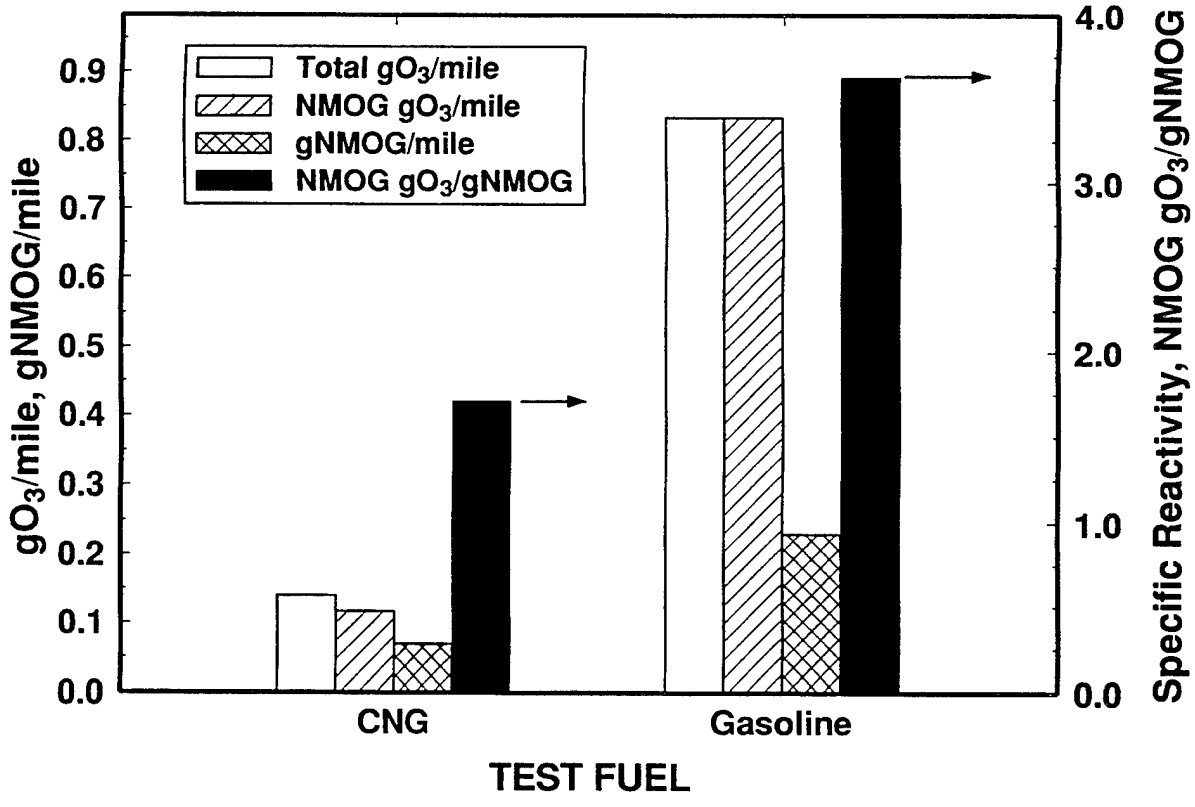


Figure 12. Effects of methane on ozone formation and specific reactivity of test fuels

Figure 12 also displays the NMOG-emitted mass and the Specific Reactivity (SR) for each fuel. The SR is a measure of the potential ozone reactivity of the NMOG emissions of a vehicle/fuel combination. The SR for a fuel is defined in Reference 13 as the summation of the mass of potential ozone formed by the individual NMOG species divided by the summation of the emitted mass of the individual NMOG species, as shown in Equation 1.

$$SR_{fuel} = \frac{\sum_{fuel} \frac{gNMOG_i}{mile} \times MIR_i \left(\frac{gO_3}{gNMOG}\right)}{\sum_{fuel} \frac{gNMOG_i}{mile}} = \frac{gO_3}{gNMOG} \qquad \text{(Eq. 1)}$$

Reference 13 also defines the Reactivity Adjustment Factor (RAF) for alternate fuel vehicles, which compares the SR of an alternative fuel to the SR of the reference fuel. In this case, the RAF is calculated utilizing the SR's for CNG and gasoline, as shown in Equation 2.

$$RAF_{CNG} = \frac{SR_{CNG}}{SR_{Gasoline}} = \frac{1.7069 \frac{gO_3}{gNMOG}}{3.6279 \frac{gO_3}{gNMOG}} = 0.47 \qquad \text{(Eq. 2)}$$

The RAF indicates the Ft. Bliss CNG vehicles have an ozone-forming potential from the NMOG constituents which is only 47 percent of, or 53 percent lower, than the gasoline control vehicle. The Ft. Bliss RAF value is in good agreement with the proposed CARB generic RAF value for CNG vehicles of 0.43 (13), which is an average RAF for seven unique CNG vehicles. The difference in the Ft. Bliss and CARB RAF values may be attributed to the number of compounds in the speciation protocol, the reference gasoline utilized, and the engine displacement difference between the Ft. Bliss CNG and gasoline vehicles.

VI. CONCLUSIONS

The following conclusions can be reached from the Ft. Bliss demonstration of dedicated CNG vehicles:

- The program was successful in that it showed that compressed natural gas can be utilized in slightly modified conventional gasoline engines. However, it also demonstrated that the reliance of a single fuel, limited refuel options, and the inherent limited range with CNG can impose severe limitations as to how the vehicles are employed relative to gasoline vehicles.

- The problems that surfaced with hardware deficiencies, i.e., gaseous fuel injectors, throttle body assemblies, regulator assemblies, etc., greatly hindered the acceptability of the dedicated CNG vehicles.

- The sudden termination of the CNG fleet and more importantly, the reason for termination and final disposition of CNG vehicles impeded the assessment of the following:

  - vehicle performance after improved fuel component hardware replacements;

  - user acceptability after installation of a 10 equivalent gallon bed-mounted CNG fuel tank for extended range;

  - evaluation of exhaust emissions versus time in CNG test and gasoline control vehicles.

- From the data obtained from fuel sheets and drivers' daily log entries, there was a 25 percent reduction observed in fuel economy for the CNG vehicles compared to the unleaded gasoline vehicles. Factors that may have contributed to this substantial difference are as follows:

- data entry errors in fuel sheets and daily log cards;

- duty cycle differences between test and control vehicles;

- converted test vehicle engines not optimized for CNG;

- possible differences in fuel economy between the 5.7 and 5.0-liter engines in spite of the EPA Fuel Economy Report.

A 15 and 11 percent reduction in fuel economy was observed during the FTP and HFET emissions testing procedure in the CNG vehicles, respectively. Converted test vehicle engines not optimized for CNG and differences in fuel economy between the 5.7- and 5.0-liter engines may be contributing factors for the difference in fuel economy between the CNG and gasoline vehicles.

- The CNG-powered vehicles have shown superior nonmethane hydrocarbons, oxides of nitrogen, and nonmethane organic gases emissions performance relative to gasoline-powered vehicles. They do, however, show increased carbon monoxide and total hydrocarbon emissions.

- The higher THC and CO emission data for the CNG vehicles indicate incomplete combustion relative to gasoline which would partially account for some of the fuel economy variation.

- The speciated emissions allow the calculation of a RAF, as defined by CARB, for potential ozone formation from NMOG for the Ft. Bliss CNG vehicles. The RAF's suggest the CNG fleet is producing only 47 percent of the potential ozone that a comparable gasoline fleet would produce from the NMOG exhaust constituents.

VII. RECOMMENDATIONS

- Improvements in CNG vehicle conversion technologies have been achieved. Additional CNG fleet demonstration programs should be conducted with light-duty trucks and possibly full and mid-sized sedans using the latest technology to elucidate all the problems that surfaced from the unfinished fleet demonstration at Ft. Bliss, Texas.

- In order to minimize interference with daily operational schedules and maximize user acceptability of compressed natural gas, consideration should be given to bi-fueled vehicles rather than single-fueled dedicated vehicles.

VIII. LIST OF REFERENCES

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4. Interagency Agreement Number DE-AI01-92CE50352, 23 September 1992.
5. Data Collection Responsibilities, Techniques, and Test Procedures, July 1992. NREL/TP-421-4894.
6. Site Operators Guide for CNG Vehicles Operating in El Paso, Texas.
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10. Liss, W.E. and Thrasher, W.H. "Natural Gas as a Stationary Engine and Vehicular Fuel," Society of Automotive Engineers (SAE), Paper No. 912364, 1991.

11. Code of Federal Regulations Title 40: Part 86, Subpart B, "Emission Regulations for 1977 and Later Model Year, New Light Duty Vehicles and New Light Duty Trucks Test Procedure."

12. Springer, K.J., Smith, L.R., and Dickinson, A.G. "Effect on CNG Start-Gasoline Run on Emissions From a 3/4-ton Pickup Truck," Society of Automotive Engineers (SAE), Paper No. 94916, 1994.

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APPENDIX A

Mileage and Fuel Usage Summaries for the Test and Control Vehicles

GSA Tag No. 4267029 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	188	15.0	12.5	188	15.0	12.5
November						
December						
January						
February	309	34.2	9.0	497	49.2	10.1
March	451	45.7	9.9	948	94.9	10.0
April	493	44.8	11.0	1441	139.7	10.3
May	529	47.7	11.1	1970	187.4	10.5
June	481	46.2	10.4	2451	233.6	10.5
July	503	46.2	10.9	2954	279.8	10.6
August	292	31.8	9.2	3246	311.6	10.4
September	328	31.2	10.5	3574	342.8	10.4
October	454	45.6	10.0	4028	388.4	10.4
November	318	34.6	9.2	4346	423.0	10.3
December	212	24.1	8.8	4558	447.1	10.2
January	292	30.1	9.7	4850	477.2	10.2
February						

GSA Tag No. 4267030 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	186	16.1	11.6	186	16.1	11.6
November	165	17.0	9.7	351	33.1	10.6
December	206	21.1	9.8	557	54.2	10.3
January	49	5.0	9.8	606	59.2	10.2
February	260	28.5	9.1	866	87.7	9.9
March	180	18.8	9.6	1046	106.5	9.8
April	305	30.6	10.0	1351	137.1	9.9
May	446	41.1	10.9	1797	178.2	10.1
June	341	27.6	12.4	2138	205.8	10.4
July	118	16.9	7.0	2256	222.7	10.1
August	474	39.0	12.2	2730	261.7	10.4
September	302	24.5	12.3	3032	286.2	10.6
October	75	5.5	13.6	3107	291.7	10.7
November	214	17.7	12.1	3321	309.4	10.7
December	97	11.5	8.4	3418	320.9	10.7
January	144	25.3	5.7	3562	346.2	10.3
February	170	7.5	22.7	3732	353.7	10.6

GSA Tag No. 4267031 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	130	13.3	9.8	130	13.3	9.8
November	69	5.2	13.3	199	18.5	10.8
December	75	4.4	17.0	274	22.9	12.0
January	96	8.5	11.3	370	31.4	11.8
February	141	11.9	11.8	511	43.3	11.8
March	40	6.0	6.7	551	49.3	11.2
April	210	10.1	20.8	761	59.4	12.8
May	73	11.6	6.3	834	71.0	11.7
June	105	11.9	8.8	939	82.9	11.3
July	86	5.5	15.6	1025	88.4	11.6
August	223	20.1	11.1	1248	108.5	11.5
September	186	20.1	9.3	1434	128.6	11.2
October						
November	133	14.1	9.4	1567	142.7	11.0
December						
January						
February						

GSA Tag No. 4267032 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	304	25.2	12.1	304	25.2	12.1
November	186	14.3	13.0	490	39.5	12.4
December	373	27.9	13.4	863	67.4	12.8
January	448	35.7	12.5	1311	103.1	12.7
February	474	39.2	12.1	1785	142.3	12.5
March	405	34.4	11.8	2190	176.7	12.4
April	569	47.1	12.1	2759	223.8	12.3
May	191	21.4	8.9	2950	245.2	12.0
June	231	26.1	8.9	3181	271.3	11.7
July	98	11.8	8.3	3279	283.1	11.6
August	217	24.3	8.9	3496	307.4	11.4
September	117	13.3	8.8	3613	320.7	11.3
October	150	15.7	9.6	3763	336.4	11.2
November	212	21.6	9.8	3975	358.0	11.1
December	109	12.0	9.1	4084	370.0	11.0
January	100	12.2	8.2	4184	382.2	10.9
February						

GSA Tag No. 4267033 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	434	28.2	15.4	434	28.2	15.4
November	273	19.5	14.0	707	47.7	14.8
December	179	20.5	8.7	886	68.2	13.0
January	382	20.3	18.8	1268	88.5	14.3
February	129	12.0	10.8	1397	100.5	13.9
March	141	12.2	11.6	1538	112.7	13.6
April	261	24.7	10.6	1799	137.4	13.1
May	124	11.6	10.7	1923	149.0	12.9
June						
July						
August						
September	285	18.1	15.7	2208	167.1	13.2
October	136	15.5	8.8	2344	182.6	12.8
November	125	6.6	18.9	2469	189.2	13.0
December	273	32.8	8.3	2742	222.0	12.4
January	466	36.2	12.9	3208	258.2	12.4
February	54	6.1	8.9	3262	264.3	12.3

GSA Tag No. 4267034 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	84	8.5	9.9	84	8.5	9.9
November	467	34.5	13.5	551	43.0	12.8
December	138	8.0	17.3	689	51.0	13.5
January	132	9.3	14.2	821	60.3	13.6
February	146	14.9	9.8	967	75.2	12.9
March	559	45.5	12.3	1526	120.7	12.6
April	245	24.2	10.1	1771	144.9	12.2
May	120	13.3	9.0	1891	158.2	12.0
June	161	17.3	9.3	2052	175.5	11.7
July	145	11.6	12.5	2197	187.1	11.7
August	238	21.8	10.9	2435	208.9	11.7
September	206	16.9	12.2	2641	225.8	11.7
October	162	23.2	7.0	2803	249.0	11.3
November	65	9.6	6.8	2868	258.6	11.1
December	104	12.7	8.2	2972	271.3	11.0
January						
February						

GSA Tag No. 4267035 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	153	10.3	14.9	153	10.3	14.9
November	292	17.4	16.8	445	27.7	16.1
December	378	23.0	16.4	823	50.7	16.2
January	319	21.2	15.0	1142	71.9	15.9
February	311	25.4	12.2	1453	97.3	14.9
March	478	40.4	11.8	1931	137.7	14.0
April	205	17.8	11.5	2136	155.5	13.7
May	315	31.6	10.0	2451	187.1	13.1
June	378	35.4	10.7	2829	222.5	12.7
July	297	22.8	13.0	3126	245.3	12.7
August	243	24.5	9.9	3369	269.8	12.5
September	427	41.1	10.4	3796	310.9	12.2
October	281	30.7	9.2	4077	341.6	11.9
November	126	14.6	8.6	4203	356.2	11.8
December	110	13.1	8.4	4313	369.3	11.7
January	187	18.0	10.4	4500	387.3	11.6
February						

GSA Tag No. 4267036 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	241	20.7	11.6	241	20.7	11.6
November	392	28.1	14.0	633	48.8	13.0
December	216	14.7	14.7	849	63.5	13.4
January	361	27.5	13.1	1210	91.0	13.3
February	499	35.9	13.9	1709	126.9	13.5
March	415	32.9	12.6	2124	159.8	13.3
April	763	64.4	11.8	2887	224.2	12.9
May	725	50.2	14.4	3612	274.4	13.2
June	479	37.9	12.6	4091	312.3	13.1
July	290	21.1	13.7	4381	333.4	13.1
August	226	13.8	16.4	4607	347.2	13.3
September	255	22.1	11.5	4862	369.3	13.2
October	105	12.7	8.3	4967	382.0	13.0
November	162	16.8	9.6	5129	398.8	12.9
December	149	15.0	9.9	5278	413.8	12.8
January	490	36.2	13.5	5768	450.0	12.8
February						

GSA Tag No. 4267037 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	351	29.8	11.8	351	29.8	11.8
November						
December						
January						
February	1019	53.1	19.2	1370	82.9	16.5
March	824	56.3	14.6	2194	139.2	15.8
April	828	35.6	23.3	3022	174.8	17.3
May						
June	875	57.1	15.3	3897	231.9	16.8
July	320	29.6	10.8	4217	261.5	16.1
August	592	43.8	13.5	4809	305.3	15.8
September	296	31.4	9.4	5105	336.7	15.2
October	288	32.7	8.8	5393	369.4	14.6
November	240	24.6	9.8	5633	394.0	14.3
December	114	14.3	8.0	5747	408.3	14.1
January	243	28.0	8.7	5990	436.3	13.7
February						

GSA Tag No. 4267038 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	224	16.6	13.5	224	16.6	13.5
November						
December	142	16.3	8.7	366	32.9	11.1
January	318	19.1	16.6	684	52.0	13.2
February	703	46.2	15.2	1387	98.2	14.1
March	424	32.6	13.0	1811	130.8	13.8
April	443	32.2	13.8	2254	163.0	13.8
May	230	21.3	10.8	2484	184.3	13.5
June	380	34.1	11.1	2864	218.4	13.1
July	160	11.6	13.8	3024	230.0	13.1
August	146	15.7	9.3	3170	245.7	12.9
September	196	14.3	13.7	3366	260.0	12.9
October	206	21.9	9.4	3572	281.9	12.7
November	421	43.4	9.7	3993	325.3	12.3
December	417	43.7	9.5	4410	369.0	12.0
January	573	56.7	10.1	4983	425.7	11.7
February	124	11.4	10.9	5107	437.1	11.7

GSA Tag No. 4267039 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	732	46.1	15.9	732	46.1	15.9
November	724	52.1	13.9	1456	98.2	14.8
December	377	29.4	12.8	1833	127.6	14.4
January	588	40.0	14.7	2421	167.6	14.4
February	495	38.5	12.9	2916	206.1	14.1
March	770	57.4	13.4	3686	263.5	14.0
April	897	64.9	13.8	4583	328.4	14.0
May	702	53.2	13.2	5285	381.6	13.8
June	758	63.6	11.9	6043	445.2	13.6
July	473	40.4	11.7	6516	485.6	13.4
August	705	61.4	11.5	7221	547.0	13.2
September	755	59.3	12.7	7976	606.3	13.2
October	591	59.2	10.0	8567	665.5	12.9
November	564	60.2	9.4	9131	725.7	12.6
December	691	70.5	9.8	9822	796.2	12.3
January	465	44.9	10.4	10287	841.1	12.2
February						

GSA Tag No. 4267040 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	411	39.7	10.4	411	39.7	10.4
November	436	39.2	11.1	847	78.9	10.7
December	789	68.8	11.5	1636	147.7	11.1
January	679	57.3	11.8	2315	205.0	11.3
February	400	42.3	9.5	2715	247.3	11.0
March	756	74.8	10.1	3471	322.1	10.8
April	102	9.4	10.9	3573	331.5	10.8
May	619	64.8	9.6	4192	396.3	10.6
June	893	91.6	9.7	5085	487.9	10.4
July	733	77.2	9.5	5818	565.1	10.3
August	762	72.3	10.5	6580	637.4	10.3
September	789	78.8	10.0	7369	716.2	10.3
October	57	6.6	8.6	7426	722.8	10.3
November	326	14.3	22.8	7752	737.1	10.5
December	192	23.4	8.2	7944	760.5	10.4
January	172	20.2	8.5	8116	780.7	10.4
February						

GSA Tag No. 4267041 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	257	19.0	13.5	257	19.0	13.5
November	253	15.7	16.1	510	34.7	14.7
December	366	25.8	14.2	876	60.5	14.5
January	185	12.2	15.2	1061	72.7	14.6
February	227	20.5	11.1	1288	93.2	13.8
March	332	27.4	12.1	1620	120.6	13.4
April	410	36.2	11.3	2030	156.8	12.9
May	384	37.5	10.2	2414	194.3	12.4
June	262	25.4	10.3	2676	219.7	12.2
July	416	42.5	9.8	3092	262.2	11.8
August	431	39.5	10.9	3523	301.7	11.7
September	382	36.9	10.4	3905	338.6	11.5
October	361	39.2	9.2	4266	377.8	11.3
November	360	37.0	9.7	4626	414.8	11.2
December	236	24.8	9.5	4862	439.6	11.1
January	451	46.7	9.7	5313	486.3	10.9
February	102	10.6	9.6	5415	496.9	10.9

GSA Tag No. 4267042 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	60	5.1	11.8	60	5.1	11.8
November	75	5.4	13.9	135	10.5	12.9
December	76	5.8	13.1	211	16.3	12.9
January	313	30.0	10.4	524	46.3	11.3
February						
March	267	20.6	13.0	791	66.9	11.8
April	144	14.7	9.8	935	81.6	11.5
May	178	14.2	12.5	1113	95.8	11.6
June	150	13.0	11.5	1263	108.8	11.6
July	159	20.8	7.6	1422	129.6	11.0
August	129	14.5	8.9	1551	144.1	10.8
September	155	13.8	11.2	1706	157.9	10.8
October	155	15.4	10.1	1861	173.3	10.7
November	143	16.1	8.9	2004	189.4	10.6
December	55	7.7	7.1	2059	197.1	10.4
January						
February	55	6.7	8.2	2114	203.8	10.4

GSA Tag No. 4267043 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	483	37.2	13.0	483	37.2	13.0
November	587	44.3	13.3	1070	81.5	13.1
December	521	40.9	12.7	1591	122.4	13.0
January	1582	89.2	17.7	3173	211.6	15.0
February	880	62.5	14.1	4053	274.1	14.8
March	860	60.4	14.2	4913	334.5	14.7
April	665	46.3	14.4	5578	380.8	14.6
May	663	53.6	12.4	6241	434.4	14.4
June	781	67.3	11.6	7022	501.7	14.0
July	742	66.6	11.1	7764	568.3	13.7
August	807	55.3	14.6	8571	623.6	13.7
September	750	57.4	13.1	9321	681.0	13.7
October	523	52.7	9.9	9844	733.7	13.4
November	424	50.9	8.3	10268	784.6	13.1
December	510	52.4	9.7	10778	837.0	12.9
January	223	23.3	9.6	11001	860.3	12.8
February	110	10.6	10.4	11111	870.9	12.8

GSA Tag No. 4267044 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	176	14.9	11.8	176	14.9	11.8
November	237	20.9	11.3	413	35.8	11.5
December	244	23.0	10.6	657	58.8	11.2
January	121	10.8	11.2	778	69.6	11.2
February	145	15.9	9.1	923	85.5	10.8
March	172	18.4	9.3	1095	103.9	10.5
April	164	13.9	11.8	1259	117.8	10.7
May	72	6.3	11.4	1331	124.1	10.7
June	124	13.2	9.4	1455	137.3	10.6
July	134	13.3	10.1	1589	150.6	10.6
August	213	20.0	10.7	1802	170.6	10.6
September	161	15.2	10.6	1963	185.8	10.6
October	44	5.6	7.9	2007	191.4	10.5
November	197	19.3	10.2	2204	210.7	10.5
December						
January						
February						

GSA Tag No. 4267045 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	280	20.0	14.0	280	20.0	14.0
November	228	13.1	17.4	508	33.1	15.3
December	280	21.3	13.1	788	54.4	14.5
January	155	12.4	12.5	943	66.8	14.1
February	153	14.0	10.9	1096	80.8	13.6
March	216	18.9	11.4	1312	99.7	13.2
April	230	21.6	10.6	1542	121.3	12.7
May	154	15.0	10.3	1696	136.3	12.4
June	182	16.6	11.0	1878	152.9	12.3
July	35	4.0	8.8	1913	156.9	12.2
August						
September						
October	79	13.4	5.9	1992	170.3	11.7
November	110	11.2	9.8	2102	181.5	11.6
December						
January						
February						

GSA Tag No. 4267046 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	352	29.1	12.1	352	29.1	12.1
November	308	25.3	12.2	660	54.4	12.1
December	359	24.8	14.5	1019	79.2	12.9
January	218	16.6	13.1	1237	95.8	12.9
February	283	24.4	11.6	1520	120.2	12.6
March	306	25.5	12.0	1826	145.7	12.5
April	380	33.1	11.5	2206	178.8	12.3
May	396	33.8	11.7	2602	212.6	12.2
June	379	34.5	11.0	2981	247.1	12.1
July	364	28.6	12.7	3345	275.7	12.1
August	257	22.3	11.5	3602	298.0	12.1
September						
October	149	10.1	14.8	3751	308.1	12.2
November	278	29.3	9.5	4029	337.4	11.9
December	59	7.7	7.7	4088	345.1	11.8
January						
February						

GSA Tag No. 4267047 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	437	35.0	12.5	437	35.0	12.5
November	390	31.8	12.3	827	66.8	12.4
December	420	28.8	14.6	1247	95.6	13.0
January	783	50.4	15.5	2030	146.0	13.9
February	552	36.8	15.0	2582	182.8	14.1
March	767	57.5	13.3	3349	240.3	13.9
April	619	47.8	12.9	3968	288.1	13.8
May	246	20.7	11.9	4214	308.8	13.6
June	37	5.1	7.3	4251	313.9	13.5
July	47	5.1	9.2	4298	319.0	13.5
August	247	25.4	9.7	4545	344.4	13.2
September	60	6.3	9.5	4605	350.7	13.1
October	143	15.7	9.1	4688	360.1	13.0
November						
December	58	6.9	8.4	4746	367.0	12.9
January						
February						

GSA Tag No. 4267048 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	449	33.9	13.2	449	33.9	13.2
November	445	34.1	13.0	894	68.0	13.1
December	133	8.9	14.9	1027	76.9	13.4
January	318	23.9	13.3	1345	100.8	13.3
February	327	28.7	11.4	1672	129.5	12.9
March	644	50.2	12.8	2316	179.7	12.9
April	408	28.0	14.6	2724	207.7	13.1
May	581	49.3	11.8	3305	257.0	12.9
June	593	45.2	13.1	3898	302.2	12.9
July	718	57.9	12.4	4616	360.1	12.8
August	698	59.4	11.8	5314	419.5	12.7
September	354	44.9	7.9	5668	464.4	12.2
October	552	58.2	9.5	6220	522.6	11.9
November	544	56.7	9.6	6764	579.3	11.7
December	179	19.4	9.2	6943	598.7	11.6
January	320	24.7	13.0	7263	623.4	11.7
February	361	40.6	8.9	7624	664.0	11.5

GSA Tag No. 4267049 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	186	15.5	12.0	186	15.5	12.0
November	194	15.2	12.8	380	30.7	12.4
December	233	12.7	18.3	613	43.4	14.1
January	205	17.2	11.9	818	60.6	13.5
February	663	55.6	11.9	1481	116.2	12.7
March	592	51.6	11.5	2073	167.8	12.4
April	709	58.4	12.1	2782	226.2	12.3
May	57	5.7	10.0	2839	231.9	12.2
June	372	38.4	9.7	3211	270.3	11.9
July	746	69.7	10.7	3957	340.0	11.6
August	697	58.4	11.9	4654	398.4	11.7
September	1014	78.6	12.9	5668	477.0	11.9
October	471	50.2	9.4	6139	527.2	11.6
November						
December						
January	310	25.0	12.4	6449	552.2	11.7
February	86	5.8	14.8	6535	558.0	11.7

GSA Tag No. 4267050 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	118	9.6	12.3	118	9.6	12.3
November						
December	76	6.5	11.7	194	16.1	12.0
January						
February	162	13.1	12.4	356	29.2	12.2
March	412	44.5	9.3	768	73.7	10.4
April	696	47.3	14.7	1464	121.0	12.1
May	350	23.9	14.6	1814	144.9	12.5
June	207	17.7	11.7	2021	162.6	12.4
July	250	28.6	8.7	2271	191.2	11.9
August	509	43.5	11.7	2780	234.7	11.8
September	719	64.1	11.2	3499	298.8	11.7
October	318	29.8	10.7	3817	328.6	11.6
November	279	28.6	9.8	4096	357.2	11.5
December	67	7.4	9.1	4163	364.6	11.4
January	360	39.0	9.2	4523	403.6	11.2
February						

GSA Tag No. 4267051 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	281	22.8	12.3	281	22.8	12.3
November	811	57.8	14.0	1092	80.6	13.5
December	862	58.3	14.8	1954	138.9	14.1
January	764	54.5	14.0	2718	193.4	14.1
February	639	49.1	13.0	3357	242.5	13.8
March	725	60.8	11.9	4082	303.3	13.5
April	763	58.1	13.1	4845	361.4	13.4
May	530	47.5	11.2	5375	408.9	13.1
June	383	40.1	9.6	5758	449.0	12.8
July	580	56.9	10.2	6338	505.9	12.5
August	535	54.2	9.9	6873	560.1	12.3
September	338	31.4	10.8	7211	591.5	12.2
October	68	8.6	7.9	7279	600.1	12.1
November	66	6.8	9.7	7345	606.9	12.1
December	149	19.6	7.6	7494	626.5	12.0
January	219	18.8	11.6	7713	645.3	12.0
February						

GSA Tag No. 4267052 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	276	27.2	10.1	276	27.2	10.1
November	128	11.9	10.8	404	39.1	10.3
December						
January						
February	101	10.9	9.3	505	50.0	10.1
March	287	26.5	10.8	792	76.5	10.4
April	440	45.8	9.6	1232	122.3	10.1
May	266	33.1	8.0	1498	155.4	9.6
June	272	32.7	8.3	1770	188.1	9.4
July	259	25.0	10.4	2029	213.1	9.5
August	213	19.6	10.9	2242	232.7	9.6
September	370	32.8	11.3	2612	265.5	9.8
October	211	28.1	7.5	2823	293.6	9.6
November	422	41.5	10.2	3245	335.1	9.7
December	355	35.0	10.1	3600	370.1	9.7
January	230	28.0	8.2	3830	398.1	9.6
February						

GSA Tag No. 4267053 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	220	17.0	12.9	220	17.0	12.9
November	270	19.9	13.6	490	36.9	13.3
December	159	13.7	11.6	649	50.6	12.8
January	226	18.0	12.6	875	68.6	12.8
February	158	22.3	7.1	1033	90.9	11.4
March	386	25.7	15.0	1419	116.6	12.2
April	271	25.0	10.8	1690	141.6	11.9
May	281	30.9	9.1	1971	172.5	11.4
June	383	40.3	9.5	2354	212.8	11.1
July	329	29.8	11.0	2683	242.6	11.1
August	220	32.0	6.9	2903	274.6	10.6
September	274	28.8	9.5	3177	303.4	10.5
October	289	32.1	9.0	3466	335.5	10.3
November	118	14.5	8.1	3584	350.0	10.2
December	70	9.0	7.8	3654	359.0	10.2
January	125	13.8	9.1	3779	372.8	10.1
February						

GSA Tag No. 4267054 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	526	40.0	13.2	526	40.0	13.2
November	158	15.7	10.1	684	55.7	12.3
December						
January	191	16.8	11.4	875	72.5	12.1
February	438	45.8	9.6	1313	118.3	11.1
March	547	49.6	11.0	1860	167.9	11.1
April	556	49.0	11.3	2416	216.9	11.1
May	527	49.8	10.6	2943	266.7	11.0
June	615	60.1	10.2	3558	326.8	10.9
July	436	40.2	10.8	3994	367.0	10.9
August	547	51.0	10.7	4541	418.0	10.9
September	522	47.7	10.9	5063	465.7	10.9
October	451	46.7	9.7	5514	512.4	10.8
November	436	45.3	9.6	5950	557.7	10.7
December	372	38.7	9.6	6322	596.4	10.6
January	343	39.5	8.7	6665	635.9	10.5
February	76	7.5	10.1	6741	643.4	10.5

GSA Tag No. 4267055 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	356	31.8	11.2	356	31.8	11.2
November	207	18.5	11.2	563	50.3	11.2
December	224	20.9	10.7	787	71.2	11.1
January	427	36.9	11.6	1214	108.1	11.2
February	253	29.3	8.6	1467	137.4	10.7
March	263	28.8	9.1	1730	166.2	10.4
April	249	27.5	9.1	1979	193.7	10.2
May	393	42.9	9.2	2372	236.6	10.0
June	361	42.7	8.5	2733	279.3	9.8
July	356	40.9	8.7	3089	320.2	9.6
August	224	26.7	8.4	3313	346.9	9.6
September	339	33.4	10.1	3652	380.3	9.6
October	265	27.0	9.8	3917	407.3	9.6
November	289	25.9	11.2	4206	433.2	9.7
December	190	26.1	7.3	4396	459.3	9.6
January	326	41.5	7.9	4722	500.8	9.4
February						

GSA Tag No. 4267056 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	206	25.4	8.1	206	25.4	8.1
November	373	21.8	17.1	579	47.2	12.3
December	387	30.5	12.7	966	77.7	12.4
January	426	36.6	11.6	1392	114.3	12.2
February	296	28.2	10.5	1688	142.5	11.8
March	405	38.2	10.6	2093	180.7	11.6
April	426	39.1	10.9	2519	219.8	11.5
May	438	44.9	9.8	2957	264.7	11.2
June	695	66.5	10.5	3652	331.2	11.0
July	423	40.5	10.4	4075	371.7	11.0
August	614	75.3	8.2	4689	447.0	10.5
September	618	47.5	13.0	5307	494.5	10.7
October	748	63.6	11.8	6055	558.1	10.8
November	414	44.4	9.3	6469	602.5	10.7
December	371	41.6	8.9	6840	644.1	10.6
January	598	60.1	10.0	7438	704.2	10.6
February	73	6.4	11.4	7511	710.6	10.6

GSA Tag No. 4267057 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	262	21.4	12.2	262	21.4	12.2
November	337	27.1	12.4	599	48.5	12.4
December	483	38.6	12.5	1082	87.1	12.4
January	442	34.7	12.7	1524	121.8	12.5
February	721	34.6	20.8	2245	156.4	14.4
March	639	36.6	17.5	2884	193.0	14.9
April	1050	53.0	19.8	3934	246.0	16.0
May	631	56.2	11.2	4565	302.2	15.1
June	526	19.7	26.7	5091	321.9	15.8
July	449	36.5	12.3	5540	358.4	15.5
August	500	48.1	10.4	6040	406.5	14.9
September	480	49.4	9.7	6520	455.9	14.3
October	590	67.3	8.8	7110	523.2	13.6
November	593	67.3	8.8	7703	590.5	13.0
December	411	49.6	8.3	8114	640.1	12.7
January	888	92.3	9.6	9002	732.4	12.3
February						

GSA Tag No. 4267058 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	286	24.5	11.7	286	24.5	11.7
November	412	32.1	12.8	698	56.6	12.3
December	437	34.1	12.8	1135	90.7	12.5
January	58	4.1	14.1	1193	94.8	12.6
February	260	23.5	11.1	1453	118.3	12.3
March	295	32.6	9.0	1748	150.9	11.6
April	395	37.9	10.4	2143	188.8	11.4
May	431	41.9	10.3	2574	230.7	11.2
June	567	58.3	9.7	3141	289.0	10.9
July	374	43.5	8.6	3515	332.5	10.6
August	399	36.1	11.1	3914	368.6	10.6
September	300	32.2	9.3	4214	400.8	10.5
October	408	40.3	10.1	4622	441.1	10.5
November	307	33.8	9.1	4929	474.9	10.4
December	473	55.5	8.5	5402	530.4	10.2
January	507	41.1	12.3	5909	571.5	10.3
February						

GSA Tag No. 4267059 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	649	42.8	15.2	649	42.8	15.2
November	480	30.9	15.5	1129	73.7	15.3
December	528	30.1	17.5	1657	103.8	16.0
January	371	28.9	12.8	2028	132.7	15.3
February	441	33.7	13.1	2469	166.4	14.8
March	511	53.3	9.6	2980	219.7	13.6
April	733	57.6	12.7	3713	277.3	13.4
May						
June	652	54.2	12.0	4365	331.5	13.2
July	241	23.7	10.2	4606	355.2	13.0
August	1108	82.6	13.4	5714	437.8	13.1
September	378	27.7	13.6	6092	465.5	13.1
October	147	13.7	10.7	6239	479.2	13.0
November	266	17.9	14.9	6505	497.1	13.1
December	574	43.9	13.1	7079	541.0	13.1
January	391	41.6	9.4	7470	582.6	12.8
February						

GSA Tag No. 4267060 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	179	13.8	13.0	179	13.8	13.0
November	266	19.5	13.6	445	33.3	13.4
December	314	27.7	11.3	759	61.0	12.4
January	118	11.1	10.6	877	72.1	12.2
February	140	14.7	9.5	1017	86.8	11.7
March	500	44.5	11.2	1517	131.3	11.6
April	141	13.2	10.7	1658	144.5	11.5
May	239	18.9	12.6	1897	163.4	11.6
June	501	47.3	10.6	2398	210.7	11.4
July	233	24.6	9.5	2631	235.3	11.2
August	662	53.5	12.4	3293	288.8	11.4
September	308	28.3	10.9	3601	317.1	11.4
October	270	19.2	14.1	3871	336.3	11.5
November	178	29.0	6.1	4049	365.3	11.1
December	421	40.9	10.3	4470	406.2	11.0
January	535	51.4	10.4	5005	457.6	10.9
February						

GSA Tag No. 4267061 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	315	28.0	11.3	315	28.0	11.3
November	379	30.9	12.3	694	58.9	11.8
December	439	35.5	12.4	1133	94.4	12.0
January	258	29.5	8.7	1391	123.9	11.2
February	454	40.1	11.3	1845	164.0	11.3
March	1283	93.3	13.8	3128	257.3	12.2
April	2045	153.0	13.4	5173	410.3	12.6
May	292	25.2	11.6	5465	435.5	12.5
June						
July						
August	1060	104.5	10.1	6525	540.0	12.1
September	960	88.8	10.8	7485	628.8	11.9
October	161	18.4	8.8	7646	647.2	11.8
November	650	58.2	11.2	8296	705.4	11.8
December	249	21.8	11.4	8545	727.2	11.8
January	574	54.4	10.6	9119	781.6	11.7
February						

GSA Tag No. 4267062 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	382	32.6	11.7	382	32.6	11.7
November	499	38.7	12.9	881	71.3	12.4
December	362	29.1	12.4	1243	100.4	12.4
January	508	36.9	13.8	1751	137.3	12.8
February	555	45.7	12.1	2306	183.0	12.6
March	691	60.5	11.4	2997	243.5	12.3
April	816	67.2	12.1	3813	310.7	12.3
May	550	55.2	10.0	4363	365.9	11.9
June	738	73.7	10.0	5101	439.6	11.6
July	601	56.1	10.7	5702	495.7	11.5
August	589	50.8	11.6	6291	546.5	11.5
September	466	44.8	10.4	6757	591.3	11.4
October	275	35.9	7.7	7032	627.2	11.2
November	408	38.8	10.5	7440	666.0	11.2
December	170	13.4	12.7	7610	679.4	11.2
January	573	57.1	10.0	8183	736.5	11.1
February						

GSA Tag No. 4267063 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	598	50.0	12.0	598	50.0	12.0
November	53	7.8	6.8	651	57.8	11.3
December	555	42.8	13.0	1206	100.6	12.0
January	530	36.8	14.4	1736	137.4	12.6
February	608	43.1	14.1	2344	180.5	13.0
March	555	35.1	15.8	2899	215.6	13.4
April	902	63.4	14.2	3801	279.0	13.6
May	740	56.6	13.1	4541	335.6	13.5
June	703	51.9	13.5	5244	387.5	13.5
July	522	41.0	12.7	5766	428.5	13.5
August	491	43.0	11.4	6257	471.5	13.3
September	388	35.4	11.0	6645	506.9	13.1
October	400	42.9	9.3	7045	549.8	12.8
November	493	47.4	10.4	7538	597.2	12.6
December	435	50.2	8.7	7973	647.4	12.3
January	442	53.3	8.3	8415	700.7	12.0
February	83	10.5	7.9	8498	711.2	11.9

GSA Tag No. 4267064 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	130	12.1	10.7	130	12.1	10.7
November						
December	90	3.7	24.3	220	15.8	13.9
January	98	8.3	11.8	318	24.1	13.2
February	63	5.1	12.4	381	29.2	13.0
March	180	16.9	10.7	561	46.1	12.2
April	283	25.1	11.3	844	71.2	11.9
May	223	22.2	10.0	1067	93.4	11.4
June	225	21.8	10.3	1292	115.2	11.2
July	156	16.9	9.2	1448	132.1	11.0
August	327	27.4	11.9	1775	159.5	11.1
September	257	23.1	11.1	2032	182.6	11.1
October	200	19.5	10.3	2232	202.1	11.0
November	136	15.0	9.1	2368	217.1	10.9
December	53	5.6	9.5	2421	222.7	10.9
January	175	18.8	9.3	2596	241.5	10.7
February						

GSA Tag No. 4267065 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	104	9.2	11.3	104	9.2	11.3
November	231	20.1	11.5	335	29.3	11.4
December	165	15.0	11.0	500	44.3	11.3
January	365	31.6	11.6	865	75.9	11.4
February	195	20.0	9.8	1060	95.9	11.1
March	375	34.8	10.8	1435	130.7	11.0
April	470	42.5	11.1	1905	173.2	11.0
May	259	26.1	9.9	2164	199.3	10.9
June	362	35.2	10.3	2526	234.5	10.8
July	724	44.5	16.3	3250	279.0	11.6
August	523	46.9	11.2	3773	325.9	11.6
September	547	46.3	11.8	4320	372.2	11.6
October	112	7.1	15.8	4432	379.3	11.7
November	209	17.9	11.7	4641	397.2	11.7
December	104	13.1	7.9	4745	410.3	11.6
January						
February	53	2.8	18.9	4798	413.1	11.6

GSA Tag No. 4267066 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	122	9.5	12.8	122	9.5	12.8
November	546	43.7	12.5	668	53.2	12.6
December	468	34.7	13.5	1136	87.9	12.9
January	430	31.3	13.7	1566	119.2	13.1
February	458	39.5	11.6	2024	158.7	12.8
March	579	46.1	12.6	2603	204.8	12.7
April	1493	120.1	12.4	4096	324.9	12.6
May	304	23.8	12.8	4400	348.7	12.6
June	640	57.5	11.1	5040	406.2	12.4
July	2081	186.4	11.2	7121	592.6	12.0
August	426	38.6	11.0	7547	631.2	12.0
September	631	54.2	11.6	8178	685.4	11.9
October	363	37.6	9.7	8541	723.0	11.8
November	495	42.4	11.7	9036	765.4	11.8
December	573	57.3	10.0	9609	822.7	11.7
January	328	41.7	7.9	9937	864.4	11.5
February	129	15.7	8.2	10066	880.1	11.4

GSA Tag No. 4267067 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	463	33.9	13.7	463	33.9	13.7
November						
December	154	11.9	12.9	617	45.8	13.5
January	645	43.0	15.0	1262	88.8	14.2
February	439	37.6	11.7	1701	126.4	13.5
March	709	59.6	11.9	2410	186.0	13.0
April	717	63.2	11.3	3127	249.2	12.5
May	732	65.0	11.3	3859	314.2	12.3
June	1169	103.5	11.3	5028	417.7	12.0
July	771	71.4	10.8	5799	489.1	11.9
August	802	71.7	11.2	6601	560.8	11.8
September	859	73.5	11.7	7460	634.3	11.8
October	550	62.1	8.9	8010	696.4	11.5
November	574	61.1	9.4	8584	757.5	11.3
December	373	38.1	9.8	8957	795.6	11.3
January	475	52.1	9.1	9432	847.7	11.1
February	165	17.9	9.2	9597	865.6	11.1

GSA Tag No. 4267068 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	63	5.6	11.3	63	5.6	11.3
November	299	28.0	10.7	362	33.6	10.8
December	398	33.0	12.1	760	66.6	11.4
January	567	45.0	12.6	1327	111.6	11.9
February	405	34.6	11.7	1732	146.2	11.8
March	326	31.9	10.2	2058	178.1	11.6
April	356	32.7	10.9	2414	210.8	11.5
May	564	55.3	10.2	2978	266.1	11.2
June	394	38.6	10.2	3372	304.7	11.1
July	175	20.0	8.8	3547	324.7	10.9
August	346	37.8	9.2	3893	362.5	10.7
September	332	32.6	10.2	4225	395.1	10.7
October	514	53.5	9.6	4739	448.6	10.6
November	424	46.0	9.2	5163	494.6	10.4
December	304	34.8	8.7	5467	529.4	10.3
January	422	40.6	10.4	5889	570.0	10.3
February						

GSA Tag No. 4267069 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	377	35.2	10.7	377	35.2	10.7
November	946	78.6	12.0	1323	113.8	11.6
December	949	76.6	12.4	2272	190.4	11.9
January	1006	85.0	11.8	3278	275.4	11.9
February	1134	104.3	10.9	4412	379.7	11.6
March	1650	131.8	12.5	6062	511.5	11.9
April	1194	95.1	12.6	7256	606.6	12.0
May	1782	152.8	11.7	9038	759.4	11.9
June	1579	123.4	12.8	10617	882.8	12.0
July	344	30.9	11.1	10961	913.7	12.0
August	1794	158.5	11.3	12755	1072.2	11.9
September	2083	168.9	12.3	14838	1241.1	12.0
October	330	28.9	11.4	15168	1270.0	11.9
November	191	15.8	12.1	15359	1285.8	11.9
December	145	13.7	10.6	15504	1299.5	11.9
January	205	26.1	7.9	15709	1325.6	11.9
February	55	5.3	10.4	15764	1330.9	11.8

GSA Tag No. 4267070 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	343	25.8	13.3	343	25.8	13.3
November	453	30.1	15.0	796	55.9	14.2
December	224	14.0	16.0	1020	69.9	14.6
January	255	18.4	13.9	1275	88.3	14.4
February	628	47.4	13.2	1903	135.7	14.0
March	852	73.9	11.5	2755	209.6	13.1
April	539	47.7	11.3	3294	257.3	12.8
May	440	39.2	11.2	3734	296.5	12.6
June	209	21.3	9.8	3943	317.8	12.4
July	588	64.6	9.1	4531	382.4	11.8
August	327	31.7	10.3	4858	414.1	11.7
September	383	36.5	10.5	5241	450.6	11.6
October	277	26.3	10.5	5518	476.9	11.6
November	328	29.0	11.3	5846	505.9	11.6
December	179	17.0	10.5	6025	522.9	11.5
January	193	21.1	9.1	6218	544.0	11.4
February						

GSA Tag No. 4267071 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	443	28.8	15.4	443	28.8	15.4
November	299	24.5	12.2	742	53.3	13.9
December	537	33.5	16.0	1279	86.8	14.7
January	522	27.4	19.1	1801	114.2	15.8
February	415	30.6	13.6	2216	144.8	15.3
March	592	45.2	13.1	2808	190.0	14.8
April	564	42.6	13.2	3372	232.6	14.5
May	339	29.5	11.5	3711	262.1	14.2
June	231	21.8	10.6	3942	283.9	13.9
July	444	41.9	10.6	4386	325.8	13.5
August	213	21.8	9.8	4599	347.6	13.2
September	343	32.3	10.6	4942	379.9	13.0
October	379	37.0	10.2	5321	416.9	12.8
November						
December	414	50.7	8.2	5735	467.6	12.3
January	168	24.7	6.8	5903	492.3	12.0
February						

GSA Tag No. 4267072 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	639	46.7	13.7	639	46.7	13.7
November	152	11.9	12.8	791	58.6	13.5
December	361	25.2	14.3	1152	83.8	13.7
January	340	24.7	13.8	1492	108.5	13.8
February	603	49.1	12.3	2095	157.6	13.3
March	478	41.3	11.6	2573	198.9	12.9
April	526	46.8	11.2	3099	245.7	12.6
May	525	47.7	11.0	3624	293.4	12.4
June	551	50.1	11.0	4175	343.5	12.2
July	306	28.2	10.9	4481	371.7	12.1
August	121	12.2	9.9	4602	383.9	12.0
September	230	20.9	11.0	4832	404.8	11.9
October	155	13.2	11.7	4987	418.0	11.9
November	77	6.9	11.2	5064	424.9	11.9
December						
January	178	18.8	9.5	5242	443.7	11.8
February						

GSA Tag No. 4267073 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	318	25.7	12.4	318	25.7	12.4
November	299	24.4	12.3	617	50.1	12.3
December	326	23.9	13.6	943	74.0	12.7
January	136	14.7	9.3	1079	88.7	12.2
February	251	14.3	17.6	1330	103.0	12.9
March	361	27.7	13.0	1691	130.7	12.9
April	391	29.4	13.3	2082	160.1	13.0
May	158	13.7	11.5	2240	173.8	12.9
June	311	28.2	11.0	2551	202.0	12.6
July	281	24.6	11.4	2832	226.6	12.5
August	334	28.3	11.8	3166	254.9	12.4
September	335	27.8	12.1	3501	282.7	12.4
October	278	32.9	8.4	3779	315.6	12.0
November	341	30.5	11.2	4120	346.1	11.9
December	206	19.2	10.7	4326	365.3	11.8
January	234	23.0	10.2	4560	388.3	11.7
February	85	9.8	8.7	4645	398.1	11.7

GSA Tag No. 4267074 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	638	49.0	13.0	638	49.0	13.0
November	527	50.8	10.4	1165	99.8	11.7
December	496	31.5	15.7	1661	131.3	12.7
January	171	14.8	11.6	1832	146.1	12.5
February	148	14.4	10.3	1980	160.5	12.3
March	443	36.1	12.3	2423	196.6	12.3
April	191	15.9	12.0	2614	212.5	12.3
May	420	41.9	10.0	3034	254.4	11.9
June	308	28.1	11.0	3342	282.5	11.8
July	402	41.6	9.7	3744	324.1	11.6
August	185	9.1	20.3	3929	333.2	11.8
September	318	32.4	9.8	4247	365.6	11.6
October	452	41.5	10.9	4699	407.1	11.5
November	229	14.1	16.2	4928	421.2	11.7
December	167	19.3	8.7	5095	440.5	11.6
January	212	12.9	16.4	5307	453.4	11.7
February	58	7.1	8.2	5365	460.5	11.7

GSA Tag No. 4267075 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	69	4.9	14.1	69	4.9	14.1
November	238	19.5	12.2	307	24.4	12.6
December	369	27.5	13.4	676	51.9	13.0
January	147	11.7	12.6	823	63.6	12.9
February	359	33.6	10.7	1182	97.2	12.2
March	497	43.7	11.4	1679	140.9	11.9
April	362	34.3	10.6	2041	175.2	11.6
May	433	38.9	11.1	2474	214.1	11.6
June	569	53.0	10.7	3043	267.1	11.4
July	491	46.6	10.5	3534	313.7	11.3
August	532	52.1	10.2	4066	365.8	11.1
September	380	34.3	11.1	4446	400.1	11.1
October	208	28.4	7.3	4654	428.5	10.9
November	371	39.8	9.3	5025	468.3	10.7
December	307	34.8	8.8	5332	503.1	10.6
January	248	23.3	10.6	5580	526.4	10.6
February	114	14.4	7.9	5694	540.8	10.5

GSA Tag No. 4267076 CNG

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
October	367	29.5	12.4	367	29.5	12.4
November	409	30.1	13.6	776	59.6	13.0
December	650	46.4	14.0	1426	106.0	13.5
January	365	28.5	12.8	1791	134.5	13.3
February	435	35.0	12.4	2226	169.5	13.1
March	432	38.7	11.2	2658	208.2	12.8
April	520	49.1	10.6	3178	257.3	12.4
May	208	19.4	10.7	3386	276.7	12.2
June	1014	97.5	10.4	4400	374.2	11.8
July	375	40.1	9.4	4775	414.3	11.5
August	596	53.2	11.2	5371	467.5	11.5
September	604	53.3	11.3	5975	520.8	11.5
October	392	40.3	9.7	6367	561.1	11.3
November	549	63.2	8.7	6916	624.3	11.1
December	390	30.3	12.9	7306	654.6	11.2
January	76	10.9	7.0	7382	665.5	11.1
February						

GSA Tag No. 4270892 Gasoline

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
July	175	18.0	9.7	175	18.0	9.7
August	721	37.0	19.5	896	55.0	16.3
September	1128	39.0	28.9 *	2024	94.0	21.5
October	1076	79.0	13.6	3100	173.0	17.9
November	1100	77.0	14.3	4200	250.0	16.8
December	690	64.0	10.8	4890	314.0	15.6
January	1414	97.0	14.6	6304	411.0	15.3
February	781	53.0	14.7	7085	464.0	15.3
March	1365	63.0	21.7	8450	527.0	16.0
April	850	60.0	14.2	9300	587.0	15.8
May	1080	82.0	13.2	10380	669.0	15.5

* Questionable data

GSA Tag No. 4270894 Gasoline

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
July	447	37.4	12.0	447	37.4	12.0
August	1216	94.5	12.9	1663	131.9	12.6
September	1022	59.4	17.2	2685	191.3	14.0
October	1314	64.5	20.4	3999	255.8	15.6
November	1115	79.0	14.1	5114	334.8	15.3
December	867	62.0	14.0	5981	396.8	15.1
January	1143	88.4	12.9	7124	485.2	14.7
February	889	54.0	16.5	8013	539.2	14.9
March	1180	86.0	13.7	9193	625.2	14.7
April	1382	101.1	13.7	10575	726.3	14.6
May	466	35.5	13.1	11041	761.8	14.5

GSA Tag No. 4270895 Gasoline

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
July	402	40.0	10.1	402	40.0	10.1
August	1191	99.0	12.0	1593	139.0	11.5
September	269	38.0	7.1	1862	177.0	10.5
October	1345	98.1	13.7	3207	275.1	11.7
November	1132	83.0	13.6	4339	358.1	12.1
December	1264	94.0	13.4	5603	452.1	12.4
January	592	54.0	11.0	6195	506.1	12.2
February	561	22.1	25.4	6756	528.2	12.8
March	1500	70.5	21.3	8256	598.7	13.8
April	1430	113.0	12.7	9686	711.7	13.6
May	798	59.0	13.5	10484	770.7	13.6

GSA Tag No. 4270896 Gasoline

	Monthly			Cumulative		
Month	Miles	Gallons	mpg	Miles	Gallons	mpg
July	185	16.0	11.6	185	16.0	11.6
August	1147	95.0	12.1	1332	111.0	12.0
September	961	76.0	12.6	2293	187.0	12.3
October	1203	63.0	19.1	3496	250.0	14.0
November	945	76.0	12.4	4441	326.0	13.6
December	1163	90.0	12.9	5604	416.0	13.5
January	786	60.0	13.1	6390	476.0	13.4
February	1071	67.0	16.0	7461	543.0	13.7
March	1054	82.0	12.9	8515	625.0	13.6
April	1023	81.0	12.6	9538	706.0	13.5
May	751	49.0	15.3	10289	755.0	13.6

APPENDIX B

3-Bag EPA FTP Vehicle Emission Results of Five CNG Trucks at 4,000-Mile Interval and Two CNG Trucks at 10,000-Mile Interval

SOUTHWEST RESEARCH INSTITUTE - DEPARMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 1.0-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 02-5137-071

VEHICLE NUMBER	0780 67043	TEST 0780-1	NAT. GAS CNG NAT. GAS
VEHICLE MODEL	92 CHEVY PICKUP	DATE 3/30/93 RUN 1	FUEL DENSITY 5.689 LB/GAL
ENGINE	5.7 L (348 CID)-V-8	DYNO 2 BAG CART 2	H .244 C .740 O .007 X .010
TRANSMISSION	L4	ACTUAL ROAD LOAD 19.90 HP (14.85 KW)	
ODOMETER	5218 MILES (8395 KM)	TEST WEIGHT 5500 LBS (2494 KG)	

BAROMETER 28.95 IN HG (735.3 MM HG) DRY BULB TEMPERATURE 77.0°F (25.0°C) NOX HUMIDITY C.F. 1.003

RELATIVE HUMIDITY 52.7 PCT.

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	505.5	867.3	505.4
DRY/WET CORRECTION FACTOR, SAMP/BACK	.966/.983	.971/.983	.967/.983
MEASURED DISTANCE MILES (KM)	3.61 (5.80)	3.85 (6.20)	3.59 (5.78)
BLOWER FLOW RATE SCFM (SCMM)	551.6 (15.62)	551.1 (15.61)	550.7 (15.60)
GAS METER FLOW RATE SCFM (SCMM)	.00 (.00)	.00 (.00)	.00 (.00)
TOTAL FLOW SCF (SCM)	4647. (131.6)	7967. (225.6)	4638. (131.4)
HC SAMPLE METER/RANGE/PPM (BAG)	13.1/ 3/ 130.71	49.0/ 2/ 48.97	10.6/ 3/ 105.76
HC BCKGRD METER/RANGE/PPM	.9/ 3/ 8.98	8.7/ 2/ 8.69	.9/ 3/ 8.98
CO SAMPLE METER/RANGE/PPM	67.8/ 1/ 625.73	48.9/ 13/ 112.62	72.7/ 14/ 344.76
CO BCKGRD METER/RANGE/PPM	.3/ 1/ 2.07	.6/ 13/ 1.31	.3/ 14/ 1.21
CO2 SAMPLE METER/RANGE/PCT	90.5/ 14/ .8792	76.4/ 14/ .5969	87.4/ 14/ .8070
CO2 BCKGRD METER/RANGE/PCT	13.5/ 14/ .0458	13.4/ 14/ .0454	13.5/ 14/ .0458
NOX SAMPLE METER/RANGE/PPM (BAG) (D)	66.2/ 1/ 16.56	10.0/ 1/ 2.50	35.7/ 1/ 8.93
NOX BCKGRD METER/RANGE/PPM	.8/ 1/ .20	.6/ 1/ .15	.5/ 1/ .13
CH4 SAMPLE PPM (1.100)	108.08	40.10	89.97
CH4 BCKGRD PPM	3.51	3.30	3.24
DILUTION FACTOR	10.11	15.70	11.31
HC CONCENTRATION PPM	122.62	40.83	97.58
CO CONCENTRATION PPM	596.95	107.51	329.56
CO2 CONCENTRATION PCT	.8380	.5544	.7653
NOX CONCENTRATION PPM	16.38	2.36	8.81
CH4 CONCENTRATION PPM	104.92	37.01	87.01
NMHC CONCENTRATION PPM	7.21	.12	1.87
THC MASS GRAMS	9.679	5.580	7.742
CO MASS GRAMS	91.460	28.240	50.400
CO2 MASS GRAMS	2019.04	2289.94	1840.47
NOX MASS GRAMS	4.135	1.022	2.221
CH4 MASS GRAMS	9.205	5.567	7.620
NMHC MASS GRAMS (FID)	.474	.013	.122
FUEL MASS KG	.800	.859	.710
FUEL ECONOMY MPG (L/100KM)	11.63 (20.23)	11.58 (20.32)	13.06 (18.01)

3-BAG COMPOSITE RESULTS

THC	G/MI	1.90	CH4	G/MI	1.861
CO	G/MI	12.92	NMHC	G/MI	.038
NOX	G/MI	.55			
FUEL ECONOMY MPG (L/100KM)		11.97 (19.65)			

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COMPUTER PROGRAM LDT 1.0-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 02-5137-071

VEHICLE NUMBER	0291 67051	TEST 0291-1	NAT. GAS CNG NAT. GAS
VEHICLE MODEL	92 CHEVY PICKUP	DATE 3/30/93 RUN 1	FUEL DENSITY 5.689 LB/GAL
ENGINE	5.7 L (348 CID)-V-8	DYNO 2 BAG CART 2	H .244 C .740 O .007 X .010
TRANSMISSION	L4	ACTUAL ROAD LOAD 19.90 HP (14.85 KW)	
ODOMETER	4328 MILES (6963 KM)	TEST WEIGHT 5500 LBS (2494 KG)	

BAROMETER 28.96 IN HG (735.6 MM HG) DRY BULB TEMPERATURE 75.0°F (23.9°C) NOX HUMIDITY C.F. .933

RELATIVE HUMIDITY 44.5 PCT.

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	505.4	867.4	505.3
DRY/WET CORRECTION FACTOR, SAMP/BACK	.968/.986	.974/.986	.970/.986
MEASURED DISTANCE MILES (KM)	3.60 (5.79)	3.85 (6.19)	3.60 (5.79)
BLOWER FLOW RATE SCFM (SCMM)	551.0 (15.60)	550.6 (15.59)	551.2 (15.61)
GAS METER FLOW RATE SCFM (SCMM)	.00 (.00)	.00 (.00)	.00 (.00)
TOTAL FLOW SCF (SCM)	4641. (131.4)	7960. (225.4)	4642. (131.5)
HC SAMPLE METER/RANGE/PPM (BAG)	13.4/ 3/ 133.70	40.4/ 2/ 40.38	63.0/ 2/ 62.96
HC BCKGRD METER/RANGE/PPM	.9/ 3/ 8.98	8.7/ 2/ 8.69	7.8/ 2/ 7.80
CO SAMPLE METER/RANGE/PPM	63.8/ 1/ 577.70	43.2/ 13/ 98.72	95.1/ 13/ 234.79
CO BCKGRD METER/RANGE/PPM	.2/ 1/ 1.38	.5/ 13/ 1.09	.6/ 13/ 1.31
CO2 SAMPLE METER/RANGE/PCT	92.3/ 14/ .9245	78.1/ 14/ .6254	88.9/ 14/ .8411
CO2 BCKGRD METER/RANGE/PCT	13.4/ 14/ .0454	13.2/ 14/ .0446	13.5/ 14/ .0458
NOX SAMPLE METER/RANGE/PPM (BAG) (D)	42.2/ 1/ 10.55	1.9/ 1/ .48	12.1/ 1/ 3.03
NOX BCKGRD METER/RANGE/PPM	.5/ 1/ .13	.3/ 1/ .08	.5/ 1/ .13
CH4 SAMPLE PPM (1.100)	112.84	32.31	53.50
CH4 BCKGRD PPM	3.00	2.84	2.89
DILUTION FACTOR	9.69	15.05	11.06
HC CONCENTRATION PPM	125.65	32.26	55.87
CO CONCENTRATION PPM	552.34	94.47	224.39
CO2 CONCENTRATION PCT	.8838	.5838	.7994
NOX CONCENTRATION PPM	10.44	.41	2.91
CH4 CONCENTRATION PPM	110.15	29.66	50.87
NMHC CONCENTRATION PPM	4.48	-.37	-.08
THC MASS GRAMS	9.946	4.457	4.458
CO MASS GRAMS	84.521	24.794	34.344
CO2 MASS GRAMS	2126.83	2409.58	1924.19
NOX MASS GRAMS	2.448	.163	.683
CH4 MASS GRAMS	9.652	4.457	4.458
NMHC MASS GRAMS (FID)	.294	.000	.000
FUEL MASS KG	.836	.900	.728
FUEL ECONOMY MPG (L/100KM)	11.10 (21.19)	11.04 (21.31)	12.77 (18.42)

3-BAG COMPOSITE RESULTS

THC	G/MI	1.51	CH4	G/MI	1.497
CO	G/MI	10.84	NMHC	G/MI	.017
NOX	G/MI	.22			
FUEL ECONOMY MPG (L/100KM)		11.49 (20.47)			

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COMPUTER PROGRAM LDT 1.0-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 02-5137-071

VEHICLE NUMBER 0259 67047
VEHICLE MODEL 92 CHEVY PICKUP
ENGINE 5.7 L (348 CID)-V-8
TRANSMISSION L4
ODOMETER 4231 MILES (6807 KM)

TEST 0259-1
DATE 5/ 5/93 RUN 1
DYNO 2 BAG CART 2
ACTUAL ROAD LOAD 19.90 HP (14.85 KW)
TEST WEIGHT 5500 LBS (2494 KG)

NAT. GAS CNG NAT. GAS
FUEL DENSITY 5.752 LB/GAL
H .237 C .727 O .009 X .028

BAROMETER 29.05 IN HG (737.9 MM HG)
RELATIVE HUMIDITY 61.5 PCT.
DRY BULB TEMPERATURE 73.0°F (22.8°C)
NOX HUMIDITY C.F. 1.010

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	505.7	867.3	505.5
DRY/WET CORRECTION FACTOR, SAMP/BACK	.965/.982	.971/.982	.966/.982
MEASURED DISTANCE MILES (KM)	3.57 (5.74)	3.83 (6.17)	3.57 (5.74)
BLOWER FLOW RATE SCFM (SCMM)	554.0 (15.69)	553.7 (15.68)	553.2 (15.67)
GAS METER FLOW RATE SCFM (SCMM)	.00 (.00)	.00 (.00)	.00 (.00)
TOTAL FLOW SCF (SCM)	4670. (132.2)	8004. (226.7)	4661. (132.0)
HC SAMPLE METER/RANGE/PPM (BAG)	97.0/ 2/ 96.94	56.2/ 5/ 28.17	72.1/ 2/ 72.06
HC BCKGRD METER/RANGE/PPM	7.4/ 2/ 7.40	17.1/ 5/ 8.57	7.8/ 2/ 7.80
CO SAMPLE METER/RANGE/PPM	75.1/ 14/ 358.49	40.4/ 12/ 39.28	93.5/ 13/ 230.27
CO BCKGRD METER/RANGE/PPM	.1/ 14/ .40	.6/ 12/ .57	.4/ 13/ .87
CO2 SAMPLE METER/RANGE/PCT	92.0/ 14/ .9168	77.5/ 14/ .6152	88.7/ 14/ .8364
CO2 BCKGRD METER/RANGE/PCT	13.2/ 14/ .0446	13.3/ 14/ .0450	14.1/ 14/ .0482
NOX SAMPLE METER/RANGE/PPM (BAG) (D)	74.3/ 1/ 18.58	5.6/ 1/ 1.40	17.4/ 1/ 4.35
NOX BCKGRD METER/RANGE/PPM	.7/ 1/ .18	.6/ 1/ .15	.6/ 1/ .15
CH4 SAMPLE PPM (1.120)	78.52	20.87	60.51
CH4 BCKGRD PPM	3.29	3.25	3.24
DILUTION FACTOR	10.08	15.57	11.19
HC CONCENTRATION PPM	90.28	20.15	64.96
CO CONCENTRATION PPM	341.34	37.27	219.25
CO2 CONCENTRATION PCT	.8766	.5731	.7926
NOX CONCENTRATION PPM	18.43	1.26	4.22
CH4 CONCENTRATION PPM	75.55	17.84	57.57
NMHC CONCENTRATION PPM	5.66	.17	.48
THC MASS GRAMS	7.120	2.719	5.105
CO MASS GRAMS	52.551	9.834	33.692
CO2 MASS GRAMS	2122.37	2378.35	1915.30
NOX MASS GRAMS	4.706	.552	1.075
CH4 MASS GRAMS	6.661	2.695	5.066
NMHC MASS GRAMS (FID)	.459	.024	.039
FUEL MASS KG	.813	.877	.724
FUEL ECONOMY MPG (L/100KM)	11.46 (20.53)	11.40 (20.63)	12.86 (18.29)

3-BAG COMPOSITE RESULTS

THC	G/MI	1.17	CH4	G/MI	1.141
CO	G/MI	6.98	NMHC	G/MI	.033
NOX	G/MI	.43			
FUEL ECONOMY MPG (L/100KM)		11.79 (19.95)			

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COMPUTER PROGRAM LDT 1.0-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 02-5137-073

VEHICLE NUMBER 67057	TEST 67057-4K-F	NAT. GAS CNG
VEHICLE MODEL 91 GMC PICKUP 2500	DATE 8/ 4/93 RUN	FUEL DENSITY 5.731 LB/GAL
ENGINE 5.5 L (335 CID)-V-8	DYNO 2 BAG CART 2	H .238 C .729 O .013 X .01
TRANSMISSION L4	ACTUAL ROAD LOAD 19.90 HP (14.85 KW)	DUMMY FUEL SPECS.
ODOMETER 5646 MILES (9084 KM)	TEST WEIGHT 5500 LBS (2494 KG)	

BAROMETER 29.36 IN HG (745.7 MM HG) DRY BULB TEMPERATURE 79.0°F (26.1°C) NOX HUMIDITY C.F. 1.005
RELATIVE HUMIDITY 50.2 PCT.

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	505.8	868.4	505.6
DRY/WET CORRECTION FACTOR, SAMP/BACK	.964/.983	.971/.983	.966/.983
MEASURED DISTANCE MILES (KM)	3.63 (5.83)	3.89 (6.26)	3.63 (5.84)
BLOWER FLOW RATE SCFM (SCMM)	562.2 (15.92)	561.8 (15.91)	561.5 (15.90)
GAS METER FLOW RATE SCFM (SCMM)	.00 (.00)	.00 (.00)	.00 (.00)
TOTAL FLOW SCF (SCM)	4740. (134.2)	8132. (230.3)	4731. (134.0)
HC SAMPLE METER/RANGE/PPM (BAG)	13.2/ 3/ 131.71	36.4/ 2/ 36.38	9.7/ 3/ 96.78
HC BCKGRD METER/RANGE/PPM	1.0/ 3/ 9.98	9.7/ 2/ 9.69	1.1/ 3/ 10.98
CO SAMPLE METER/RANGE/PPM	53.5/ 1/ 461.60	60.4/ 12/ 59.12	86.4/ 13/ 210.44
CO BCKGRD METER/RANGE/PPM	.2/ 1/ 1.38	.5/ 12/ .47	.4/ 13/ .87
CO2 SAMPLE METER/RANGE/PCT	51.1/ 1/ .9411	78.0/ 14/ .6237	88.7/ 14/ .8364
CO2 BCKGRD METER/RANGE/PCT	2.7/ 1/ .0470	13.8/ 14/ .0470	13.1/ 14/ .0442
NOX SAMPLE METER/RANGE/PPM (BAG) (D)	71.6/ 1/ 17.91	3.7/ 1/ .93	37.0/ 1/ 9.25
NOX BCKGRD METER/RANGE/PPM	.5/ 1/ .13	.4/ 1/ .10	.0/ 1/ .00
DILUTION FACTOR	9.69	15.28	11.17
HC CONCENTRATION PPM	122.76	27.32	86.79
CO CONCENTRATION PPM	440.10	56.64	201.07
CO2 CONCENTRATION PCT	.8990	.5798	.7962
NOX CONCENTRATION PPM	17.80	.83	9.25
FIDHC MASS GRAMS	11.283	4.308	7.963
CO MASS GRAMS	68.774	15.185	31.365
CO2 MASS GRAMS	2209.34	2444.67	1953.27
NOX MASS GRAMS	4.590	.368	2.383
FUEL MASS KG	.862	.910	.743
FUEL ECONOMY MPG (L/100KM)	10.94 (21.51)	11.11 (21.18)	12.70 (18.52)

3-BAG COMPOSITE RESULTS

FIDHC G/MI	1.82
CO G/MI	8.33
NOX G/MI	.49
FUEL ECONOMY MPG (L/100KM)	11.48 (20.49)

SOUTHWEST RESEARCH INSTITUTE - DEPARMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 1.0-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 02-5137-073

VEHICLE NUMBER 67059
VEHICLE MODEL 92 CHEVY PICKUP
ENGINE 5.7 L (348 CID)-V-8
TRANSMISSION L4
ODOMETER 6196 MILES (9969 KM)

TEST 670594K-F
DATE 10/ 7/93 RUN 1
DYNO 2 BAG CART 2
ACTUAL ROAD LOAD 19.90 HP (14.85 KW)
TEST WEIGHT 5500 LBS (2494 KG)

NAT. GAS CNG NAT GAS
FUEL DENSITY 5.793 LB/GAL
H .235 C .723 O .012 X .029

BAROMETER 29.27 IN HG (743.5 MM HG) DRY BULB TEMPERATURE 74.0°F (23.3°C) NOX HUMIDITY C.F. .999
RELATIVE HUMIDITY 58.1 PCT.

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	505.4	867.9	505.4
DRY/WET CORRECTION FACTOR, SAMP/BACK	.965/.983	.971/.983	.967/.983
MEASURED DISTANCE MILES (KM)	3.64 (5.86)	3.90 (6.27)	3.65 (5.87)
BLOWER FLOW RATE SCFM (SCMM)	558.8 (15.83)	558.4 (15.81)	558.7 (15.82)
GAS METER FLOW RATE SCFM (SCMM)	.14 (.00)	.14 (.00)	.14 (.00)
TOTAL FLOW SCF (SCM)	4708. (133.3)	8079. (228.8)	4707. (133.3)
HC SAMPLE METER/RANGE/PPM (BAG)	12.6/ 3/ 125.72	41.6/ 2/ 41.58	10.4/ 3/ 103.77
HC BCKGRD METER/RANGE/PPM	.8/ 3/ 7.98	8.6/ 2/ 8.60	1.0/ 3/ 9.98
CO SAMPLE METER/RANGE/PPM	84.6/ 14/ 413.67	57.8/ 12/ 56.51	68.7/ 14/ 322.15
CO BCKGRD METER/RANGE/PPM	.3/ 14/ 1.21	1.4/ 12/ 1.33	.4/ 14/ 1.62
CO2 SAMPLE METER/RANGE/PCT	49.6/ 1/ .9135	77.3/ 14/ .6118	88.5/ 14/ .8318
CO2 BCKGRD METER/RANGE/PCT	2.7/ 1/ .0470	13.6/ 14/ .0462	14.1/ 14/ .0482
NOX SAMPLE METER/RANGE/PPM (BAG) (D)	25.3/ 2/ 25.33	12.0/ 1/ 3.00	38.8/ 1/ 9.70
NOX BCKGRD METER/RANGE/PPM	.2/ 2/ .20	.9/ 1/ .23	.8/ 1/ .20
CH4 SAMPLE PPM (1.120)	102.69	33.03	86.07
CH4 BCKGRD PPM	3.64	3.37	3.38
DILUTION FACTOR	10.05	15.61	11.12
HC CONCENTRATION PPM	118.53	33.53	94.69
CO CONCENTRATION PPM	393.74	53.22	306.79
CO2 CONCENTRATION PCT	.8712	.5686	.7880
NOX CONCENTRATION PPM	25.15	2.79	9.52
CH4 CONCENTRATION PPM	99.41	29.88	82.99
NMHC CONCENTRATION PPM	7.19	.07	1.73
THC MASS GRAMS	9.422	4.567	7.517
CO MASS GRAMS	61.119	14.175	47.613
CO2 MASS GRAMS	2126.66	2381.92	1923.19
NOX MASS GRAMS	6.403	1.219	2.424
CH4 MASS GRAMS	8.837	4.557	7.376
NMHC MASS GRAMS (FID)	.585	.010	.141
FUEL MASS KG	.823	.885	.739
FUEL ECONOMY MPG (L/100KM)	11.63 (20.22)	11.57 (20.33)	12.97 (18.14)

3-BAG COMPOSITE RESULTS

THC	G/MI	1.71	CH4	G/MI	1.665
CO	G/MI	8.96	NMHC	G/MI	.045
NOX	G/MI	.71			
FUEL ECONOMY MPG (L/100KM)		11.95 (19.69)			

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 1.2-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 02-5137-073

VEHICLE NUMBER	67043	TEST 67043-10K-F	NAT. GAS CNG NAT GAS
VEHICLE MODEL	92 CHEVY PICKUP	DATE 1/25/94 RUN 1	FUEL DENSITY 5.793 LB/GAL
ENGINE	5.7 L (348 CID)-V-8	DYNO 2 BAG CART 2	H .235 C .723 O .012 X .029
TRANSMISSION	L4	ACTUAL ROAD LOAD 19.90 HP (14.85 KW)	FTP
ODOMETER	11255 MILES (18109 KM)	TEST WEIGHT 5500 LBS (2494 KG)	

BAROMETER 29.23 IN HG (742.4 MM HG) DRY BULB TEMPERATURE 78.0°F (25.6°C) NOX HUMIDITY C.F. 1.069

RELATIVE HUMIDITY 60.1 PCT.

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	512.1	867.9	505.3
DRY/WET CORRECTION FACTOR, SAMP/BACK	.963/.980	.968/.980	.964/.980
MEASURED DISTANCE MILES (KM)	3.66 (5.88)	3.89 (6.26)	3.63 (5.85)
BLOWER FLOW RATE SCFM (SCMM)	563.0 (15.95)	563.5 (15.96)	563.6 (15.96)
GAS METER FLOW RATE SCFM (SCMM)	.14 (.00)	.14 (.00)	.13 (.00)
TOTAL FLOW SCF (SCM)	4807. (136.1)	8153. (230.9)	4748. (134.5)
HC SAMPLE METER/RANGE/PPM (BAG)	12.4/ 3/ 123.72	48.6/ 2/ 48.57	10.1/ 3/ 100.78
HC BCKGRD METER/RANGE/PPM	.8/ 3/ 7.98	8.4/ 2/ 8.40	1.0/ 3/ 9.98
CO SAMPLE METER/RANGE/PPM	97.9/ 14/ 491.21	87.3/ 12/ 87.26	67.7/ 14/ 316.55
CO BCKGRD METER/RANGE/PPM	.3/ 14/ 1.21	.6/ 12/ .57	.2/ 14/ .81
CO2 SAMPLE METER/RANGE/PCT	90.4/ 14/ .8768	76.3/ 14/ .5952	87.4/ 14/ .8070
CO2 BCKGRD METER/RANGE/PCT	12.8/ 14/ .0430	12.8/ 14/ .0430	13.5/ 14/ .0458
NOX SAMPLE METER/RANGE/PPM (BAG) (D)	59.5/ 1/ 14.92	9.4/ 1/ 2.40	35.3/ 1/ 8.89
NOX BCKGRD METER/RANGE/PPM	.4/ 1/ .10	.0/ 1/ .00	.0/ 1/ .00
CH4 SAMPLE PPM (1.110)	103.04	38.42	83.80
CH4 BCKGRD PPM	2.77	2.76	2.82
DILUTION FACTOR	10.37	15.95	11.45
HC CONCENTRATION PPM	116.51	40.70	91.67
CO CONCENTRATION PPM	467.95	83.52	302.18
CO2 CONCENTRATION PCT	.8379	.5549	.7652
NOX CONCENTRATION PPM	14.82	2.40	8.89
CH4 CONCENTRATION PPM	100.54	35.83	81.23
NMHC CONCENTRATION PPM	4.91	.93	1.50
THC MASS GRAMS	9.532	5.646	7.404
CO MASS GRAMS	74.158	22.449	47.300
CO2 MASS GRAMS	2088.24	2345.66	1883.65
NOX MASS GRAMS	4.123	1.134	2.443
CH4 MASS GRAMS	9.124	5.516	7.281
NMHC MASS GRAMS (FID)	.408	.131	.123
FUEL MASS KG	.817	.878	.724
FUEL ECONOMY MPG (L/100KM)	11.76 (20.00)	11.66 (20.18)	13.18 (17.85)

3-BAG COMPOSITE RESULTS

THC	G/MI	1.85	CH4	G/MI	1.803
CO	G/MI	10.79	NMHC	G/MI	.050
NOX	G/MI	.57			
FUEL ECONOMY MPG (L/100KM)		12.07 (19.49)			

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 1.2-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 02-5137-073

VEHICLE NUMBER 67051
VEHICLE MODEL 92 CHEVY PICKUP
ENGINE 5.7 L (348 CID)-V-8
TRANSMISSION L4
ODOMETER 7847 MILES (12625 KM)

TEST 67051-1
DATE 1/18/94 RUN
DYNO 2 BAG CART 2
ACTUAL ROAD LOAD 19.90 HP (14.85 KW)
TEST WEIGHT 5500 LBS (2494 KG)

NAT. GAS CNG NAT GAS
FUEL DENSITY 5.793 LB/GAL
H .235 C .723 O .012 X .029
10,000 MILES

BAROMETER 29.59 IN HG (751.6 MM HG)
RELATIVE HUMIDITY 20.5 PCT.
DRY BULB TEMPERATURE 68.0°F (20.0°C)
NOX HUMIDITY C.F. .798

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	505.6	867.8	505.4
DRY/WET CORRECTION FACTOR, SAMP/BACK	.977/.995	.983/.995	.979/.995
MEASURED DISTANCE MILES (KM)	3.65 (5.88)	3.89 (6.26)	3.66 (5.88)
BLOWER FLOW RATE SCFM (SCMM)	565.9 (16.03)	568.1 (16.09)	566.9 (16.06)
GAS METER FLOW RATE SCFM (SCMM)	.14 (.00)	.14 (.00)	.14 (.00)
TOTAL FLOW SCF (SCM)	4770. (135.1)	8219. (232.8)	4776. (135.3)
HC SAMPLE METER/RANGE/PPM (BAG)	11.8/ 3/ 117.74	38.5/ 2/ 38.48	76.4/ 2/ 76.36
HC BCKGRD METER/RANGE/PPM	.6/ 3/ 5.99	5.6/ 2/ 5.60	5.6/ 2/ 5.60
CO SAMPLE METER/RANGE/PPM	64.1/ 1/ 581.24	49.4/ 13/ 113.86	74.5/ 14/ 355.04
CO BCKGRD METER/RANGE/PPM	.0/ 1/ .00	.7/ 13/ 1.52	.2/ 14/ .81
CO2 SAMPLE METER/RANGE/PCT	92.1/ 14/ .9193	77.5/ 14/ .6152	87.8/ 14/ .8159
CO2 BCKGRD METER/RANGE/PCT	14.1/ 14/ .0482	14.0/ 14/ .0478	13.7/ 14/ .0466
NOX SAMPLE METER/RANGE/PPM (BAG) (D)	54.9/ 1/ 13.77	5.3/ 1/ 1.36	28.5/ 1/ 7.20
NOX BCKGRD METER/RANGE/PPM	.8/ 1/ .21	.8/ 1/ .21	.8/ 1/ .21
CH4 SAMPLE PPM (1.110)	96.57	31.77	64.21
CH4 BCKGRD PPM	3.10	2.92	2.95
DILUTION FACTOR	9.83	15.39	11.31
HC CONCENTRATION PPM	112.36	33.24	71.25
CO CONCENTRATION PPM	561.70	109.63	343.45
CO2 CONCENTRATION PCT	.8760	.5705	.7735
NOX CONCENTRATION PPM	13.58	1.17	7.01
CH4 CONCENTRATION PPM	93.78	29.05	61.52
NMHC CONCENTRATION PPM	8.26	1.00	2.97
	2.59	1.23	1.56 5.62 ÷ 3.73
THC MASS GRAMS	9.126	4.650	5.793
CO MASS GRAMS	88.334	29.706	54.087
CO2 MASS GRAMS	2166.58	2431.23	1915.54
NOX MASS GRAMS	2.799	.414	1.446
CH4 MASS GRAMS	8.446	4.507	5.548
NMHC MASS GRAMS (FID)	.681	.143	.245
FUEL MASS KG	.853	.912	.738
FUEL ECONOMY MPG (L/100KM)	11.25 (20.90)	11.22 (20.97)	13.01 (18.08)

3-BAG COMPOSITE RESULTS

THC	G/MI	1.57	CH4	G/MI	1.497
CO	G/MI	13.05	NMHC	G/MI	.076
NOX	G/MI	.32			
FUEL ECONOMY MPG (L/100KM)		11.68 (20.14)			

APPENDIX C

1-Bag HFET EPA FTP Vehicle Emission Results of Three CNG Trucks at 4,000-Mile Interval and One CNG Truck at 10,000-Mile Interval

SOUTHWEST RESEARCH INSTITUTE - DEPARMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 1.0-R 1-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 02-5137-071

VEHICLE NUMBER 0259 67047
VEHICLE MODEL 92 CHEVY PICKUP
ENGINE 5.7 L (348 CID)-V-8
TRANSMISSION L4
ODOMETER 4242 MILES (6825 KM)

TEST 0259-1
DATE 5/ 5/93 RUN 1
DYNO 2 BAG CART 2
ACTUAL ROAD LOAD 19.90 HP (14.85 KW)
TEST WEIGHT 5500 LBS (2494 KG)

NAT. GAS CNG NAT. GAS
FUEL DENSITY 5.752 LB/GAL
H .237 C .727 O .009 X .028

BAROMETER 29.07 IN HG (738.4 MM HG)
RELATIVE HUMIDITY 55.6 PCT.

DRY BULB TEMPERATURE 76.0°F (24.4°C)

NOX HUMIDITY C.F. 1.009

BAG NUMBER	1
BAG DESCRIPTION	
RUN TIME SECONDS	765.2
DRY/WET CORRECTION FACTOR, SAMP/BACK	.961/.983
MEASURED DISTANCE MILES (KM)	10.24 (16.47)
BLOWER FLOW RATE SCFM (SCMM)	552.2 (15.64)
GAS METER FLOW RATE SCFM (SCMM)	.00 (.00)
TOTAL FLOW SCF (SCM)	7043. (199.5)
HC SAMPLE METER/RANGE/PPM (BAG)	82.3/ 2/ 82.25
HC BCKGRD METER/RANGE/PPM	6.1/ 2/ 6.10
CO SAMPLE METER/RANGE/PPM	95.4/ 14/ 476.78
CO BCKGRD METER/RANGE/PPM	.4/ 14/ 1.62
CO2 SAMPLE METER/RANGE/PCT	60.5/ 1/ 1.1139
CO2 BCKGRD METER/RANGE/PCT	2.7/ 1/ .0470
NOX SAMPLE METER/RANGE/PPM (BAG) (D)	42.8/ 1/ 10.70
NOX BCKGRD METER/RANGE/PPM	.6/ 1/ .15
CH4 SAMPLE PPM (1.120)	66.59
CH4 BCKGRD PPM	2.62
DILUTION FACTOR	8.29
HC CONCENTRATION PPM	76.89
CO CONCENTRATION PPM	451.20
CO2 CONCENTRATION PCT	1.0726
NOX CONCENTRATION PPM	10.57
CH4 CONCENTRATION PPM	64.29
NMHC CONCENTRATION PPM	4.89
THC MASS GRAMS	9.146
CO MASS GRAMS	104.768
CO2 MASS GRAMS	3916.73
NOX MASS GRAMS	4.070
CH4 MASS GRAMS	8.548
NMHC MASS GRAMS (FID)	.598
FUEL MASS KG	1.500
FUEL ECONOMY MPG (L/100KM)	17.81 (13.21)

1-BAG COMPOSITE RESULTS

THC	G/MI	.89	CH4	G/MI	.835
CO	G/MI	10.23	NMHC	G/MI	.058
NOX	G/MI	.40			
FUEL ECONOMY MPG (L/100KM)		17.81 (13.21)			

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 1.2-R 1-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 02-5137-073

VEHICLE NUMBER	67057	TEST 67057-4K-H	NAT. GAS CNG NAT. GAS
VEHICLE MODEL	91 CHEVY PICKUP	DATE 8/ 4/93 RUN 1	FUEL DENSITY 5.752 LB/GAL
ENGINE	5.5 L (335 CID)-V-8	DYNO 2 BAG CART 2	H .237 C .727 O .009 X .028
TRANSMISSION	L4	ACTUAL ROAD LOAD 19.90 HP (14.85 KW)	
ODOMETER	5657 MILES (9102 KM)	TEST WEIGHT 5500 LBS (2494 KG)	

BAROMETER 29.37 IN HG (746.0 MM HG) DRY BULB TEMPERATURE 78.0°F (25.6°C) NOX HUMIDITY C.F. 1.066

RELATIVE HUMIDITY 60.0 PCT.

BAG NUMBER	1
BAG DESCRIPTION	
RUN TIME SECONDS	765.2
DRY/WET CORRECTION FACTOR, SAMP/BACK	.958/.980
MEASURED DISTANCE MILES (KM)	10.34 (16.64)
BLOWER FLOW RATE SCFM (SCMM)	561.5 (15.90)
GAS METER FLOW RATE SCFM (SCMM)	.00 (.00)
TOTAL FLOW SCF (SCM)	7162. (202.8)
HC SAMPLE METER/RANGE/PPM (BAG)	12.1/ 3/ 120.73
HC BCKGRD METER/RANGE/PPM	1.3/ 3/ 12.97
CO SAMPLE METER/RANGE/PPM	60.8/ 1/ 542.78
CO BCKGRD METER/RANGE/PPM	.1/ 1/ .69
CO2 SAMPLE METER/RANGE/PCT	61.3/ 1/ 1.1286
CO2 BCKGRD METER/RANGE/PCT	2.5/ 1/ .0435
NOX SAMPLE METER/RANGE/PPM (BAG) (D)	37.7/ 1/ 9.43
NOX BCKGRD METER/RANGE/PPM	.0/ 1/ .00
CH4 SAMPLE PPM (1.120)	97.67
CH4 BCKGRD PPM	3.80
DILUTION FACTOR	8.12
HC CONCENTRATION PPM	109.36
CO CONCENTRATION PPM	513.64
CO2 CONCENTRATION PCT	1.0905
NOX CONCENTRATION PPM	9.43
CH4 CONCENTRATION PPM	94.34
NMHC CONCENTRATION PPM	3.70
THC MASS GRAMS	13.216
CO MASS GRAMS	121.280
CO2 MASS GRAMS	4049.24
NOX MASS GRAMS	3.898
CH4 MASS GRAMS	12.755
NMHC MASS GRAMS (FID)	.460
FUEL MASS KG	1.562
FUEL ECONOMY MPG (L/100KM)	17.27 (13.62)

1-BAG COMPOSITE RESULTS

THC	G/MI	1.28	CH4	G/MI	1.234
CO	G/MI	11.73	NMHC	G/MI	.045
NOX	G/MI	.38			
FUEL ECONOMY MPG (L/100KM)		17.27 (13.62)			

SOUTHWEST RESEARCH INSTITUTE - DEPARMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 1.0-R HFET VEHICLE EMISSION RESULTS PROJECT NO. 02-5137-073

VEHICLE NUMBER 67059
VEHICLE MODEL 92 CHEVY PICKUP
ENGINE 5.7 L (348 CID)-V-8
TRANSMISSION L4
ODOMETER 6207 MILES (9987 KM)

TEST 670594K-H
DATE 10/ 7/93 RUN 1
DYNO 2 BAG CART 2
ACTUAL ROAD LOAD 19.90 HP (14.85 KW)
TEST WEIGHT 5500 LBS (2494 KG)

NAT. GAS CNG NAT GAS
FUEL DENSITY 5.793 LB/GAL
H .235 C .723 O .012 X .029

BAROMETER 29.28 IN HG (743.7 MM HG) DRY BULB TEMPERATURE 73.0°F (22.8°C) NOX HUMIDITY C.F. 1.006
RELATIVE HUMIDITY 61.4 PCT.

BAG NUMBER	1
BAG DESCRIPTION	HFET
RUN TIME SECONDS	765.5
DRY/WET CORRECTION FACTOR, SAMP/BACK	.961/.983
MEASURED DISTANCE MILES (KM)	10.28 (16.55)
BLOWER FLOW RATE SCFM (SCMM)	557.8 (15.80)
GAS METER FLOW RATE SCFM (SCMM)	.13 (.00)
TOTAL FLOW SCF (SCM)	7118. (201.6)
HC SAMPLE METER/RANGE/PPM (BAG)	90.7/ 2/ 90.65
HC BCKGRD METER/RANGE/PPM	9.7/ 2/ 9.69
CO SAMPLE METER/RANGE/PPM	51.5/ 14/ 229.73
CO BCKGRD METER/RANGE/PPM	.4/ 14/ 1.62
CO2 SAMPLE METER/RANGE/PCT	60.3/ 1/ 1.1102
CO2 BCKGRD METER/RANGE/PCT	2.7/ 1/ .0470
NOX SAMPLE METER/RANGE/PPM (BAG) (D)	94.5/ 1/ 23.64
NOX BCKGRD METER/RANGE/PPM	1.0/ 1/ .25
CH4 SAMPLE PPM (1.120)	75.27
CH4 BCKGRD PPM	3.30
DILUTION FACTOR	8.50
HC CONCENTRATION PPM	82.09
CO CONCENTRATION PPM	216.28
CO2 CONCENTRATION PCT	1.0688
NOX CONCENTRATION PPM	23.41
CH4 CONCENTRATION PPM	72.36
NMHC CONCENTRATION PPM	1.04
THC MASS GRAMS	9.854
CO MASS GRAMS	50.760
CO2 MASS GRAMS	3944.72
NOX MASS GRAMS	9.085
CH4 MASS GRAMS	9.725
NMHC MASS GRAMS (FID)	.128
FUEL MASS KG	1.484
FUEL ECONOMY MPG (L/100KM)	18.21 (12.92)

1-BAG COMPOSITE RESULTS

THC	G/MI	.96	CH4	G/MI	.946
CO	G/MI	4.94	NMHC	G/MI	.012
NOX	G/MI	.88			
FUEL ECONOMY MPG (L/100KM)		18.21 (12.92)			

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 1.2-R 1-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 02-5137-073

VEHICLE NUMBER 67043
VEHICLE MODEL 92 CHEVY PICKUP
ENGINE 5.7 L (348 CID)-V-8
TRANSMISSION L4
ODOMETER 11278 MILES (18146 KM)

TEST 67043-10K-H
DATE 1/25/94 RUN 1
DYNO 2 BAG CART 2
ACTUAL ROAD LOAD 19.90 HP (14.85 KW)
TEST WEIGHT 5500 LBS (2494 KG)

NAT. GAS CNG NAT GAS
FUEL DENSITY 5.793 LB/GAL
H .235 C .723 O .012 X .029

BAROMETER 29.23 IN HG (742.4 MM HG) DRY BULB TEMPERATURE 77.0°F (25.0°C) NOX HUMIDITY C.F. .999
RELATIVE HUMIDITY 52.5 PCT.

BAG NUMBER	1
BAG DESCRIPTION	
RUN TIME SECONDS	765.3
DRY/WET CORRECTION FACTOR, SAMP/BACK	.962/.983
MEASURED DISTANCE MILES (KM)	10.28 (16.54)
BLOWER FLOW RATE SCFM (SCMM)	560.5 (15.87)
GAS METER FLOW RATE SCFM (SCMM)	.14 (.00)
TOTAL FLOW SCF (SCM)	7151. (202.5)
HC SAMPLE METER/RANGE/PPM (BAG)	87.1/ 2/ 87.05
HC BCKGRD METER/RANGE/PPM	8.0/ 2/ 8.00
CO SAMPLE METER/RANGE/PPM	73.5/ 14/ 349.32
CO BCKGRD METER/RANGE/PPM	.6/ 14/ 2.43
CO2 SAMPLE METER/RANGE/PCT	57.8/ 1/ 1.0643
CO2 BCKGRD METER/RANGE/PCT	2.9/ 1/ .0505
NOX SAMPLE METER/RANGE/PPM (BAG) (D)	35.8/ 1/ 9.01
NOX BCKGRD METER/RANGE/PPM	.3/ 1/ .08
CH4 SAMPLE PPM (1.110)	72.96
CH4 BCKGRD PPM	2.93
DILUTION FACTOR	8.77
HC CONCENTRATION PPM	79.97
CO CONCENTRATION PPM	330.37
CO2 CONCENTRATION PCT	1.0196
NOX CONCENTRATION PPM	8.95
CH4 CONCENTRATION PPM	70.36
NMHC CONCENTRATION PPM	1.86
THC MASS GRAMS	9.730
CO MASS GRAMS	77.892
CO2 MASS GRAMS	3780.59
NOX MASS GRAMS	3.461
CH4 MASS GRAMS	9.500
NMHC MASS GRAMS (FID)	.230
FUEL MASS KG	1.439
FUEL ECONOMY MPG (L/100KM)	18.78 (12.53)

1-BAG COMPOSITE RESULTS

THC	G/MI	.95	CH4	G/MI	.924
CO	G/MI	7.58	NMHC	G/MI	.022
NOX	G/MI	.34			
FUEL ECONOMY MPG (L/100KM)		18.78 (12.53)			

APPENDIX D

3-Bag EPA FTP Vehicle Emission Results of Two Gasoline Trucks at 4,000-Mile Interval

SOUTHWEST RESEARCH INSTITUTE - DEPARMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 1.0-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 02-5137-073

VEHICLE NUMBER 70895
VEHICLE MODEL 92 CHEVY PICKUP
ENGINE 5.0 L (305 CID)-V-8
TRANSMISSION L4
ODOMETER 3414 MILES (5493 KM)

TEST 708954K-F
DATE 10/ 8/93 RUN 1
DYNO 2 BAG CART 2
ACTUAL ROAD LOAD 17.10 HP (12.76 KW)
TEST WEIGHT 5500 LBS (2494 KG)

GASOLINE EM-1618-F
FUEL DENSITY 6.163 LB/GAL
H .134 C .866 O .000 X .000

BAROMETER 29.11 IN HG (739.4 MM HG) DRY BULB TEMPERATURE 73.0°F (22.8°C) NOX HUMIDITY C.F. .965
RELATIVE HUMIDITY 53.9 PCT.

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	505.6	868.2	505.9
DRY/WET CORRECTION FACTOR, SAMP/BACK	.975/.985	.979/.985	.976/.985
MEASURED DISTANCE MILES (KM)	3.63 (5.85)	3.85 (6.20)	3.62 (5.83)
BLOWER FLOW RATE SCFM (SCMM)	556.0 (15.75)	559.9 (15.86)	555.1 (15.72)
GAS METER FLOW RATE SCFM (SCMM)	.14 (.00)	.14 (.00)	.13 (.00)
TOTAL FLOW SCF (SCM)	4687. (132.7)	8104. (229.5)	4681. (132.6)
HC SAMPLE METER/RANGE/PPM (BAG)	92.0/ 2/ 91.95	11.4/ 2/ 11.39	16.0/ 2/ 15.99
HC BCKGRD METER/RANGE/PPM	11.0/ 2/ 10.99	10.7/ 2/ 10.69	10.7/ 2/ 10.69
CO SAMPLE METER/RANGE/PPM	79.1/ 14/ 381.59	13.5/ 12/ 12.97	58.4/ 12/ 57.11
CO BCKGRD METER/RANGE/PPM	.1/ 14/ .40	.5/ 12/ .47	.8/ 12/ .76
CO2 SAMPLE METER/RANGE/PCT	55.1/ 1/ 1.0148	79.4/ 14/ .6481	92.7/ 14/ .9349
CO2 BCKGRD METER/RANGE/PCT	2.6/ 1/ .0452	13.9/ 14/ .0474	14.7/ 14/ .0506
NOX SAMPLE METER/RANGE/PPM (BAG) (D)	38.5/ 2/ 38.54	33.0/ 1/ 8.25	81.3/ 1/ 20.33
NOX BCKGRD METER/RANGE/PPM	.3/ 2/ .30	.9/ 1/ .23	1.0/ 1/ .25
DILUTION FACTOR	12.71	20.73	14.32
HC CONCENTRATION PPM	81.82	1.22	6.04
CO CONCENTRATION PPM	367.14	12.14	54.40
CO2 CONCENTRATION PCT	.9731	.6030	.8878
NOX CONCENTRATION PPM	38.26	8.04	20.10
HC MASS GRAMS	6.260	.161	.462
CO MASS GRAMS	56.731	3.243	8.397
CO2 MASS GRAMS	2364.63	2533.97	2155.04
NOX MASS GRAMS	9.370	3.404	4.917
FUEL MASS KG	.780	.801	.684
FUEL ECONOMY MPG (L/100KM)	13.03 (18.06)	13.46 (17.48)	14.81 (15.89)

3-BAG COMPOSITE RESULTS

HC	G/MI	.42
CO	G/MI	4.33
NOX	G/MI	1.37
FUEL ECONOMY MPG (L/100KM)		13.72 (17.15)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 1.2-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 02-5137-073

VEHICLE NUMBER 70896
VEHICLE MODEL 93 CHEVY PICKUP
ENGINE 5.7 L (348 CID)-V-8
TRANSMISSION L4
ODOMETER 7393 MILES (11895 KM)

TEST 70896-10K-F
DATE 1/25/94 RUN 1
DYNO 2 BAG CART 2
ACTUAL ROAD LOAD 17.10 HP (12.76 KW)
TEST WEIGHT 5500 LBS (2494 KG)

GASOLINE EEE EM-1638-F
FUEL DENSITY 6.160 LB/GAL
H .134 C .866 O .000 X .000
FTP

BAROMETER 29.25 IN HG (743.0 MM HG)
RELATIVE HUMIDITY 51.4 PCT.
DRY BULB TEMPERATURE 81.0°F (27.2°C)
NOX HUMIDITY C.F. 1.042

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	504.8	867.8	505.9
DRY/WET CORRECTION FACTOR, SAMP/BACK	.971/.981	.975/.981	.972/.981
MEASURED DISTANCE MILES (KM)	3.63 (5.85)	3.87 (6.23)	3.63 (5.83)
BLOWER FLOW RATE SCFM (SCMM)	564.3 (15.98)	563.0 (15.94)	563.5 (15.96)
GAS METER FLOW RATE SCFM (SCMM)	.14 (.00)	.14 (.00)	.13 (.00)
TOTAL FLOW SCF (SCM)	4749. (134.5)	8145. (230.7)	4753. (134.6)
HC SAMPLE METER/RANGE/PPM (BAG)	91.6/ 2/ 91.55	12.9/ 2/ 12.89	19.3/ 2/ 19.29
HC BCKGRD METER/RANGE/PPM	9.7/ 2/ 9.69	10.6/ 2/ 10.59	10.4/ 2/ 10.39
CO SAMPLE METER/RANGE/PPM	77.9/ 14/ 374.63	30.4/ 12/ 29.46	43.7/ 13/ 99.93
CO BCKGRD METER/RANGE/PPM	.3/ 14/ 1.21	1.3/ 12/ 1.23	.6/ 13/ 1.31
CO2 SAMPLE METER/RANGE/PCT	56.8/ 1/ 1.0460	79.6/ 14/ .6517	92.7/ 14/ .9349
CO2 BCKGRD METER/RANGE/PCT	3.1/ 1/ .0540	15.4/ 14/ .0535	15.5/ 14/ .0540
NOX SAMPLE METER/RANGE/PPM (BAG) (D)	39.4/ 2/ 39.42	37.8/ 1/ 9.51	94.5/ 1/ 23.55
NOX BCKGRD METER/RANGE/PPM	.3/ 2/ .30	.9/ 1/ .23	1.0/ 1/ .26
CH4 SAMPLE PPM (1.110)	6.93	4.09	5.08
CH4 BCKGRD PPM	2.88	2.86	2.80
DILUTION FACTOR	12.36	20.56	14.25
HC CONCENTRATION PPM	82.64	2.81	9.62
CO CONCENTRATION PPM	359.79	27.45	95.28
CO2 CONCENTRATION PCT	.9963	.6008	.8848
NOX CONCENTRATION PPM	39.14	9.29	23.31
CH4 CONCENTRATION PPM	4.29	1.37	2.47
NMHC CONCENTRATION PPM	77.88	1.30	6.88
HC MASS GRAMS	6.406	.374	.747
CO MASS GRAMS	56.328	7.371	14.930
CO2 MASS GRAMS	2453.08	2537.01	2180.25
NOX MASS GRAMS	10.485	4.269	6.249
CH4 MASS GRAMS	.384	.210	.222
NMHC MASS GRAMS (FID)	6.039	.172	.534
FUEL MASS KG	.808	.804	.695
FUEL ECONOMY MPG (L/100KM)	12.57 (18.71)	13.46 (17.48)	14.57 (16.15)

3-BAG COMPOSITE RESULTS

HC	G/MI	.47	CH4	G/MI	.067
CO	G/MI	5.35	NMHC	G/MI	.410
NOX	G/MI	1.65			
FUEL ECONOMY MPG (L/100KM)		13.56 (17.35)			

APPENDIX E

1-Bag HFET EPA FTP Vehicle Emission Results of Two Gasoline Trucks at 4,000-Mile Interval

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 1.2-R HFET VEHICLE EMISSION RESULTS PROJECT NO. 02-5137-073

VEHICLE NUMBER 70896
VEHICLE MODEL 93 CHEVY PICKUP
ENGINE 5.7 L (348 CID)-V-8
TRANSMISSION L4
ODOMETER 7435 MILES (11962 KM)

TEST 70896-10K-F
DATE 1/25/94 RUN 1
DYNO 2 BAG CART 2
ACTUAL ROAD LOAD 17.10 HP (12.76 KW)
TEST WEIGHT 5500 LBS (2494 KG)

GASOLINE EEE EM-1638-F
FUEL DENSITY 6.160 LB/GAL
H .134 C .866 O .000 X .000
H-FET

BAROMETER 29.21 IN HG (741.9 MM HG) DRY BULB TEMPERATURE 81.0°F (27.2°C) NOX HUMIDITY C.F. 1.042
RELATIVE HUMIDITY 51.4 PCT.

BAG NUMBER	1
BAG DESCRIPTION	HFET
RUN TIME SECONDS	765.2
DRY/WET CORRECTION FACTOR, SAMP/BACK	.969/.981
MEASURED DISTANCE MILES (KM)	10.23 (16.47)
BLOWER FLOW RATE SCFM (SCMM)	559.4 (15.84)
GAS METER FLOW RATE SCFM (SCMM)	.14 (.00)
TOTAL FLOW SCF (SCM)	7136. (202.1)
HC SAMPLE METER/RANGE/PPM (BAG)	10.1/ 2/ 10.09
HC BCKGRD METER/RANGE/PPM	8.4/ 2/ 8.40
CO SAMPLE METER/RANGE/PPM	36.2/ 12/ 35.15
CO BCKGRD METER/RANGE/PPM	1.1/ 12/ 1.04
CO2 SAMPLE METER/RANGE/PCT	70.0/ 1/ 1.2888
CO2 BCKGRD METER/RANGE/PCT	2.9/ 1/ .0505
NOX SAMPLE METER/RANGE/PPM (BAG) (D)	32.3/ 2/ 32.31
NOX BCKGRD METER/RANGE/PPM	.3/ 2/ .30
CH4 SAMPLE PPM (1.110)	3.16
CH4 BCKGRD PPM	2.24
DILUTION FACTOR	10.43
HC CONCENTRATION PPM	2.50
CO CONCENTRATION PPM	32.77
CO2 CONCENTRATION PCT	1.2432
NOX CONCENTRATION PPM	32.04
CH4 CONCENTRATION PPM	1.13
NMHC CONCENTRATION PPM	1.24
HC MASS GRAMS	.292
CO MASS GRAMS	7.710
CO2 MASS GRAMS	4599.89
NOX MASS GRAMS	12.909
CH4 MASS GRAMS	.153
NMHC MASS GRAMS (FID)	.145
FUEL MASS KG	1.454
FUEL ECONOMY MPG (L/100KM)	19.66 (11.96)

1-BAG COMPOSITE RESULTS

HC	G/MI	.03	CH4	G/MI	.015
CO	G/MI	.75	NMHC	G/MI	.014
NOX	G/MI	1.26			
FUEL ECONOMY MPG (L/100KM)		19.66 (11.96)			

SOUTHWEST RESEARCH INSTITUTE - DEPARMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 1.0-R HFET VEHICLE EMISSION RESULTS PROJECT NO. 02-5137-073

VEHICLE NUMBER 70895
VEHICLE MODEL 92 CHEVY PICKUP
ENGINE 5.0 L (305 CID)-V-8
TRANSMISSION L4
ODOMETER 3425 MILES (5510 KM)

TEST 708954K-A
DATE 10/ 8/93 RUN 1
DYNO 2 BAG CART 2
ACTUAL ROAD LOAD 17.10 HP (12.76 KW)
TEST WEIGHT 5500 LBS (2494 KG)

GASOLINE EM-1618-F
FUEL DENSITY 6.163 LB/GAL
H .134 C .866 O .000 X .000

BAROMETER 29.13 IN HG (739.9 MM HG) DRY BULB TEMPERATURE 76.0°F (24.4°C) NOX HUMIDITY C.F. .963
RELATIVE HUMIDITY 48.5 PCT.

BAG NUMBER	1
BAG DESCRIPTION	HFET
RUN TIME SECONDS	765.5
DRY/WET CORRECTION FACTOR, SAMP/BACK	.973/.985
MEASURED DISTANCE MILES (KM)	10.35 (16.65)
BLOWER FLOW RATE SCFM (SCMM)	553.5 (15.68)
GAS METER FLOW RATE SCFM (SCMM)	.14 (.00)
TOTAL FLOW SCF (SCM)	7064. (200.0)
HC SAMPLE METER/RANGE/PPM (BAG)	11.8/ 2/ 11.79
HC BCKGRD METER/RANGE/PPM	10.1/ 2/ 10.09
CO SAMPLE METER/RANGE/PPM	16.4/ 12/ 15.78
CO BCKGRD METER/RANGE/PPM	.5/ 12/ .47
CO2 SAMPLE METER/RANGE/PCT	69.2/ 1/ 1.2740
CO2 BCKGRD METER/RANGE/PCT	3.0/ 1/ .0523
NOX SAMPLE METER/RANGE/PPM (BAG) (D)	83.7/ 1/ 20.93
NOX BCKGRD METER/RANGE/PPM	.9/ 1/ .23
DILUTION FACTOR	10.56
HC CONCENTRATION PPM	2.65
CO CONCENTRATION PPM	14.73
CO2 CONCENTRATION PCT	1.2267
NOX CONCENTRATION PPM	20.73
HC MASS GRAMS	.306
CO MASS GRAMS	3.430
CO2 MASS GRAMS	4492.81
NOX MASS GRAMS	7.639
FUEL MASS KG	1.418
FUEL ECONOMY MPG (L/100KM)	20.40 (11.53)

1-BAG COMPOSITE RESULTS

HC	G/MI	.03
CO	G/MI	.33
NOX	G/MI	.74
FUEL ECONOMY MPG (L/100KM)		20.40 (11.53)

APPENDIX F

Speciated Emission Test Results

SPECIATED EMISSIONS TEST RESULTS
PROJECT NO. 02-5137-073

VEHICLE NUMBER		67043	67051	67047	67057	67059	70895
TEST DATE		03/30/93	03/30/93	05/05/93	08/04/93	10/07/93	10/08/93
MILAGE		5,218	4,328	4,231	5,646	6,196	3,414
TEST FUEL		CNG	CNG	CNG	CNG	CNG	GASOLINE
SELECTED COMPOUNDS (mg/mi)							
FTP	METHANE	1954.7	1487.6	1141.5	1540.6	1664.8	43.3
	ETHYLENE	11.1	9.4	8.7	10.1	8.5	22.4
	ETHANE	65.7	44.3	32.0	39.7	44.6	5.2
	ACETYLENE	1.0	0.5	0.6	0.7	1.1	10.7
	PROPYLENE	0.7	0.7	0.6	0.8	0.7	16.3
	PROPANE	7.5	5.5	4.9	5.5	5.6	0.5
	METHYLACETYLENE						0.0
	PROPADIENE	0.0	0.0	0.0	0.0	0.0	0.0
	ISOBUTANE	0.6	0.5	0.3	0.7	0.7	0.9
	ISOBUTYLENE						9.3
	1-BUTENE						2.0
	1,3-BUTADIENE	0.0	0.0	0.0	0.0	0.0	1.9
	BUTANE	1.3	0.9	1.1	1.1	1.1	12.9
	TRANS-2-BUTENE						1.7
	2, 2-DIMETHYLPROPANE						0.8
	CIS-2-BUTENE						1.6
	3-METHYL-1-BUTENE						0.0
	ISOPENTANE	0.3	0.2	0.9	0.3	1.4	23.9
	1-PENTENE						0.4
	2-METHYL-1-BUTENE	0.2	0.0	0.4	0.0	0.1	1.0
	PENTANE						8.1
	BENZENE	0.3	0.5	0.1	0.0	0.8	19.1
	TOLUENE						72.0
	ETHYLBENZENE						3.3
	m- & p-XYLENE						7.7
	MTBE						0.0
	FORMALDEHYDE	3.1	2.2	2.7	2.8	3.2	6.0
	ACETALDEHYDE	0.2	0.3	0.4	0.4	0.3	1.8
	TOTAL ALDEHYDES	3.8	3.1	*3.1	3.4	3.9	10.6

NOTES:

Light shaded areas indicate no data is available.

Dark shaded areas indicate no data is required.

* Aldehyde analyses does not include acetone, isobutyraldehyde, or methyl ethyl ketone for this test.

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